OCTOBER 1960

SAE

PUBLISHED BY THE SOCIETY OF AUTOMOTIVE ENGINEERS

JOURNAL

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A complete index of all Journal technical articles, from January through December, will appear in the December issue. All Journal technical articles are indexed by Engineering Index, Inc. SAE Journal is available on microfilm from University Microfilms, Ann Arbor, Mich.

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These digests are provided by ENGINEERING INDEX, which each year abstracts 30,000 engineering articles from 1500 different publications and classifies them into 249 "fields of engineering interest."

To order the SAE papers digested here, circle the numbers in the "Readers Information Service" blank on p. 6 corresponding to the numbers appearing after the titles of the digests of the papers you want.

AEROSPACECRAFT

Turbofan Engine and its Application Versatility, S. M. TAYLOR, C. B. BRAME. Paper No. 172A. Principles of turbofans and theri possible cycles, based on 14-yr studies, carried out by Pratt & Whitney Aircraft; comparison of jet and turbofan; results of application studies with respect to 4-engine, twin-engine, and 3-engine short range transport; 4-engine 200,000-lb, 250,000-lb, 300,000-lb, 350,000-lb transport; Fleet Air Arm (FAA) climb requirements; present equipment considerations, cargo airplane, and military applications; turbofan improves short range transport by extending range capability at no penalty in direct operating cost.

Aft Fan Engines for Commercial Transport, B. J. GORDON, R. C. HAWKINS. Paper No. 172B. Fundamentals of reaction propulsion; basic fan parameters; overall engine merit; establishment of desired cycle as high fan energy input design with bypass ratio approaching 2.0 and fan pressure ratio less than 2.0; determination of best design aproach taking advantage of cycle possibilities; aft fan concept, adopted by General Electric Co., and development of CJ805-23 engine; heart of aft fan is "blucket", lower or turbine bucket half driving upper or compressor blade portion.

Man and Space, L. CARLYLE. Paper No. 173A. Comparison of various types of manned flight useful in determining functional and volumetric requirements of human occupant; single body size is studied to establish principles for entire functional human envelope; full range of body sizes between 5th and 95th percentile values (small to large) is included in composite envelope; examination of pertinent flight factors for short orbit vehicles serving as guide for determining appropriate envelope; envelope for interplanetary vehicles.

Human Engineering Payoff, J. A. MACDONALD. Paper No. 173B. Concept adopted by Special Projects Branch, Aircraft Laboratory, Wright Air Development Div., Ohio, with respect to area of engineering which provides compatibility, efficiency, and harmony between aircraft and their human occupants and operators, i.e. human engineering; paper deals with areas of escape systems and components, restraint, sealants, vision, and crew station design and arrangement.

Analysis of V/STOL Vehicles on Payload-Range Basis, J. H. AYDELOTTE. Paper No. 174A. Configurations examined for comparative performance are tilt wing, tilting ducted engine, helicopter, and unloaded rotor; VTO capabilities are of interest in lower payload-range area and overload STOL capability is desired to as much as 10,000 lb payload with 1500 nautical mi range; these general areas are selected to include wide range of vehicle size and performance and overseas ferry capability; engine characteristics selected; design considerations.

Trends in VTOL Aircraft Propulsion System Requirements, J. B. NICHOLS. Paper No. 174B. Review of basic VTOL types from helicopter to pure jet VTOL types; it appears that quantity use of VTOL aircraft will tend to be predominant in low disk loaded types; promising type for exploitation is tilt wing type of propelloplane exemplified by X-18 aircraft undergoing tests at Hiller Aircraft Corp.; development of "integrated" aircraft, jet flap, and Ring Wing, or "Coleopter"; Lift Propulsor type, or wingless "Aerodyne" which represents pure jet lifter type of VTOL; ground effect machines.

High Energy Absorption Landing Gear for VTOL Aircraft, C. L. WHARTON, Jr. Paper No. 174C. Low speed flight regime as it applies to jet powered, VTOL, high performance aircraft is presented in comparison to similar zones existing for present day rotorcraft; safety aspects of operation

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Briefs of SAE PAPERS

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within this zone and methods of increasing landing capability; by utilizing high energy absorption, landing gear, proposed by Lockheed Aircraft Corp., power failure altitude capability above terrain can be increased to such extent that aircraft can operate without traversing extreme caution zone; design considerations.

Lifeboats for Astronauts, J. G. LOWRY, F. M. ROGALLO. Paper No. 175C. Lifeboats to provide man with device in which he can survive rigors of space, and return safely to earth from near earth orbits; device similar in size and weight to present-day parachute should have low accelerations and temperatures during reentry and stability, control, and performance required; considerations can be satisfied with low wing loading lifting reentry vehicle; flexible lifting surface concept suggested is suggested; data upon which suggestion is based; operation of emergency descent from orbit.

Recent High Temperature Bearing Developments, J. H. JOHNSON. Paper No. 176A. On basis of need for specific testing; Marlin-Rockwell Corp., Jamestown, N. Y., has begun work to evaluate performance of bearings submerged in Oronite 8200 hydraulic fluid at 450 F; purpose of program was to determine magnitude of derating required and to establish measure of bearing reliability under specific conditions of operation; phases of tests and results; fluid analysis conducted indicates that there is little deterioration of Oronite 8200 fluid as lubricant under conditions of test.

Recent Developments in High Temperature Bearings and Lubricants, P. C. HANLON. Paper No. 176B. Antifriction bearing development, developed for military flight vehicles in prototype stage and on drawing boards, at Wright Air Development Div., Dayton, Ohio, comprises airframe bearings, accessory bearings, and engine bearings; temperatures range from – 65 to 1200 F; bearing materials are available that will give satisfactory service; lubricants, however, are lacking; it appears that advance in state-of-art can be achieved only by continued concentrated efforts.

Development Progress on Gas Bearings for Airborne Accessory Equipment, C. R. ADAMS. Paper No. 176C. Externally pressurized bearing concept, developed at Boeing Airplane Co., is based on throttling gas as it leaves bearing; advantages of gas bearings and use in accessory equipment; hardware integration and manufacturing problems; experimental efforts; development of step bearings and manufacturing techniques; pressure distribution tests; modification of step bearings by means of oil-mist operation which leaves thin film acting as boundary lubricant.

NASA Research on High-Temperature Bearing Problem, W. J. ANDERSON, E. E. BISSON. Paper No. 176D. Approaches to these problems involve various types of lubricants as well as different lubrication techniques; paper considers problem areas, reviews various approaches and indicates research being done by NASA in this field; seven types of most promising systems listed. 25 refs.

What Makes High Energy Propellant?, J. D. CLARK. Paper No. 177A. Investigation to improve performance of propellant or propellant combination based on examination of exhaust products; undesirable qualities shown are presence of carbon and complicated (polyatomic) exhaust products; desirable quality giving specific impulse in gratifying quantities is system which produces large amount of hydrogen, plus highly exothermic exhaust gas to warm it up, preferably one with good R/Cp of its own.

Design Aspects of Air Breathing Booster, W. H. BOND, R. F. MAWHINNEY. Paper No. 177B. To improve cost situation, Convair, San Diego, Calif., studied technical and economic aspects of large boosters covering propulsion systems from conventional rockets to advanced air breathing systems; analysis shows that useful vehicle recovery strongly reduces cost; increasing velocity increment of recoverable stage becomes increasingly attractive as recoverability improves; design aspects of air breathing booster;

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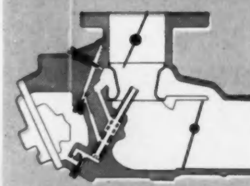

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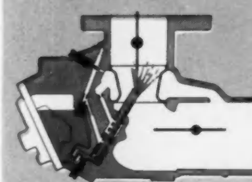

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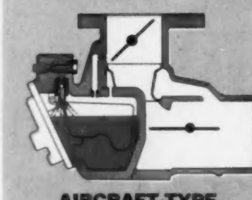

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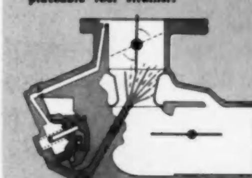

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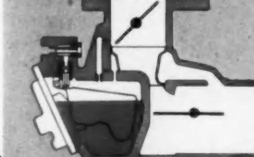

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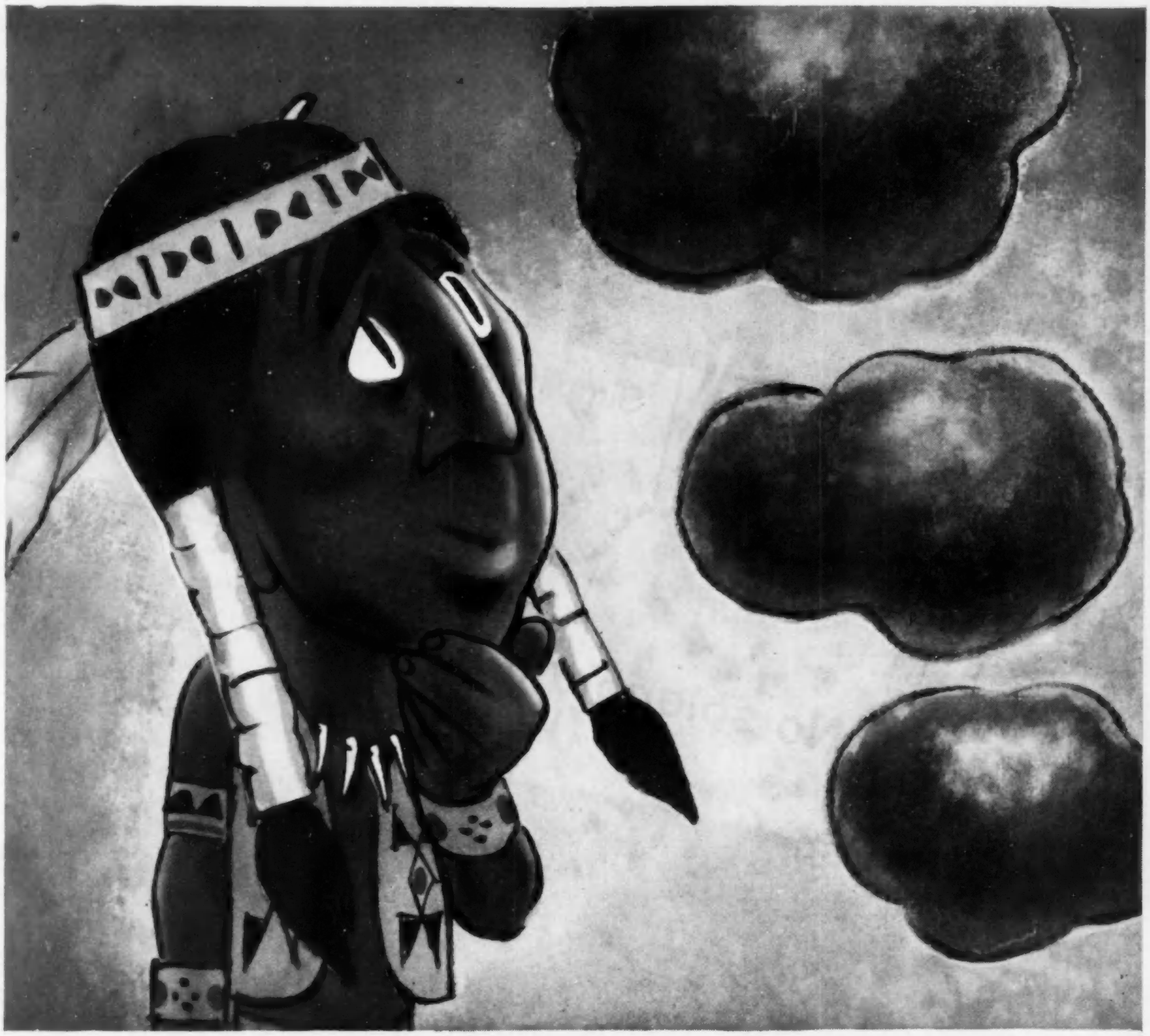

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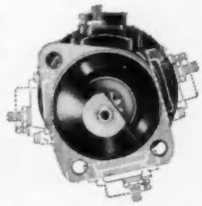

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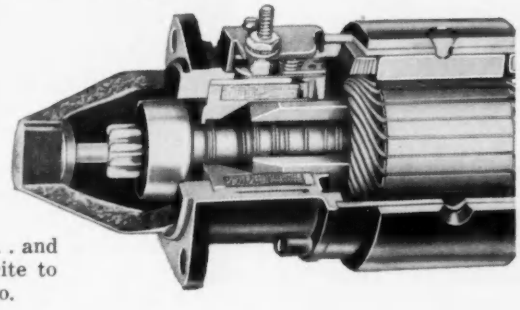

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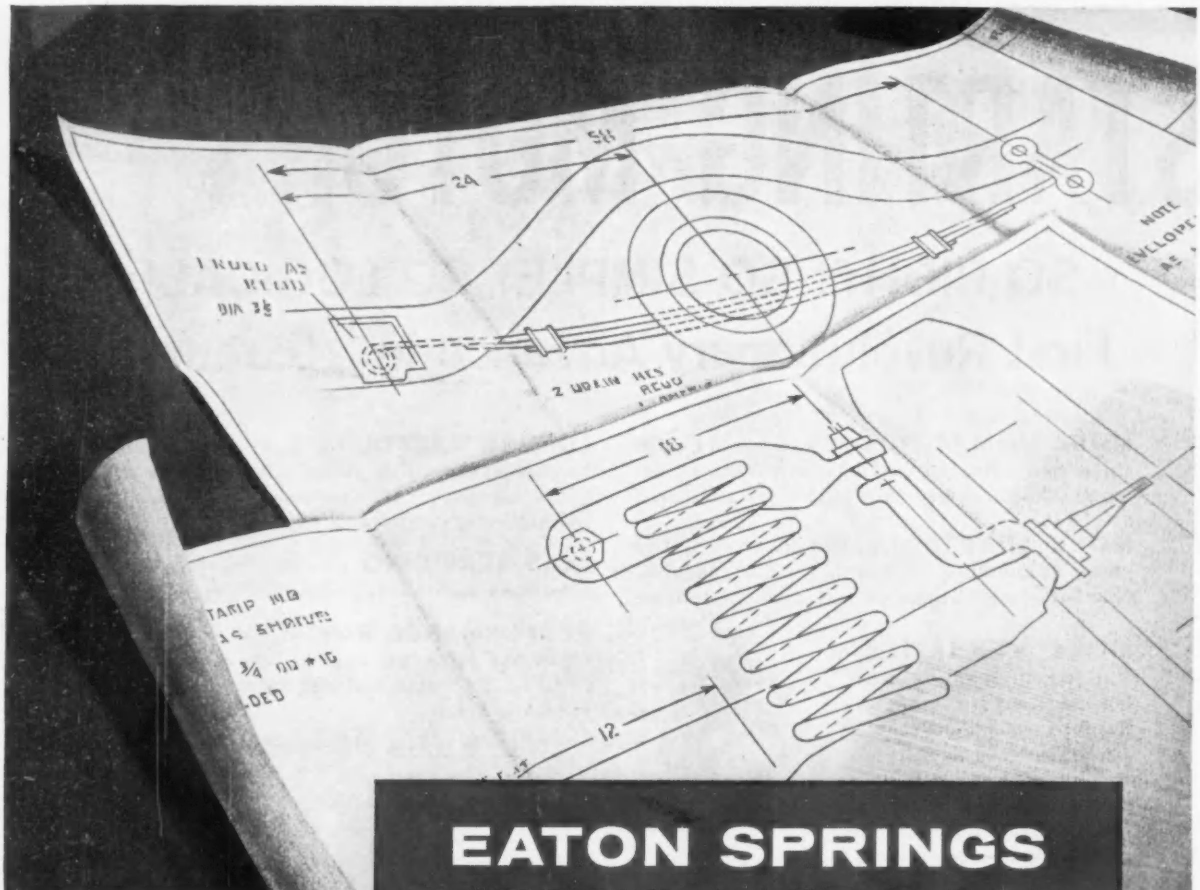

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So, remember, when you see the first astronaut smiling quietly, confidently from his capsule, you are looking at him through Corning glass.

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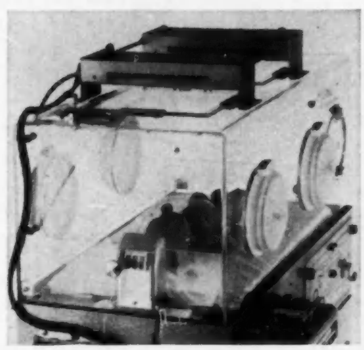
This particular machine is used with prematurely born infants who must keep their body temperature at a constant level, but lack a well-developed thermal regulatory device.

You attach a thermistor to the babe's abdomen and let him work as his own thermostat. He automatically requests heat from infrared lamps whenever his skin temperature drops below 97°F. When things are just right again, he switches off the lamps and takes a rest, with the odds for survival more in his favor.

If you've ever tried to unbulb an infrared lamp, you know that it gives off *direct* heat as well as IR energy.



That's why there are two PYREX No. 7740 glass plates sitting on top of the plastic chamber in the picture. You can see them, if you look closely. The PYREX plates are heat resistant and will also dissipate the *direct* thermal output of the lamps. So, the plastic forgets the lamps are there.

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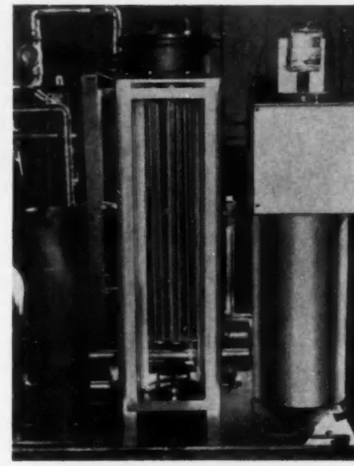

SOMETIMES GLASS IS SO OBVIOUS

Leafing our way through the 4th Annual Shirt Issue of "Cleaning Laundry World" (April 1960), we took note of an advertisement which concerned a machine which displayed a feature which we consider the soul of genius.

The machine is a dry cleaner manufactured by Detrex Chemical Industries, Inc. The feature is a glass-enclosed filter which keeps the dry-cleaning solvent cycling unpolluted. The soul of genius, to our minds, consists of intelligent manipulation of the obvious . . . in this case, an application of the first known and longest respected of the myriad properties of glass . . . to wit, its *transparency*.

When you locate such a place, it doesn't necessarily take a lot of redesigning of custom fabrication to put glass to work, either. We checked and found that Detrex, for example, simply orders standard 6" O.D. PYREX brand Heavy Duty Tube for its filter wall.

The result is that the operator of the Detrex Cleaner can watch the filter at work. He can spot trouble while it's still potential, determine its cause exactly should it occur . . . all without any dismantling or shutdown.

Is there anything you're working on that you wish you could watch working? If there is, and you want to put glass to work, you can start by sending the coupon for a copy of Bulletin IZ-1, "Designing with Glass for Industrial, Commercial, and Consumer Applications."

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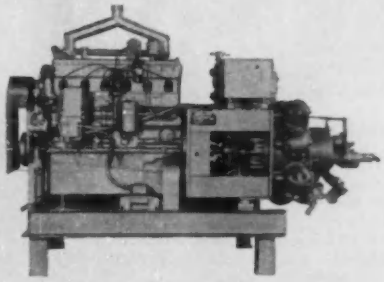

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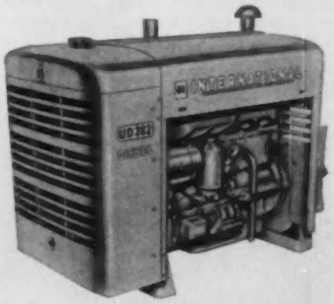
"On-the-job reports prove that International power is an excellent choice." H. P. Lockhart, Ass't General Manager, Sales, Austin-Western Construction Equipment Div., Baldwin-Lima-Hamilton Corp.



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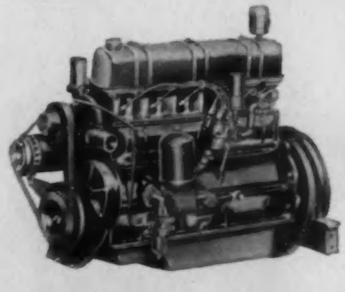

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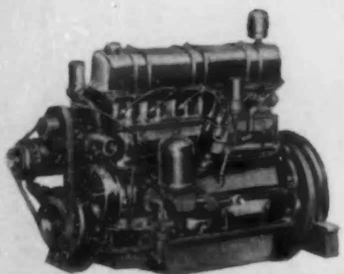
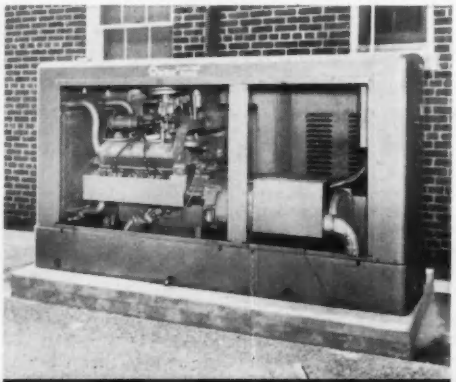
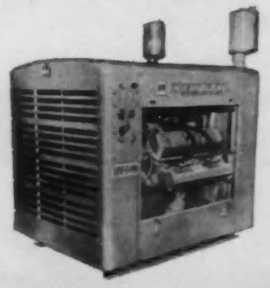
"We needed heavy-duty engines with superior sealing that would keep working under extremely dusty conditions." Report from R. Schmidt, Chief Engineer, Elgin Sweeper Co.





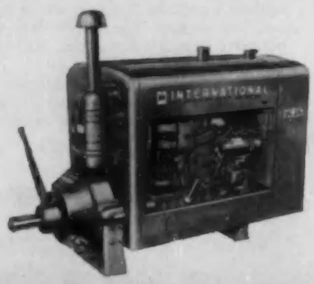
AUXILIARY POWER

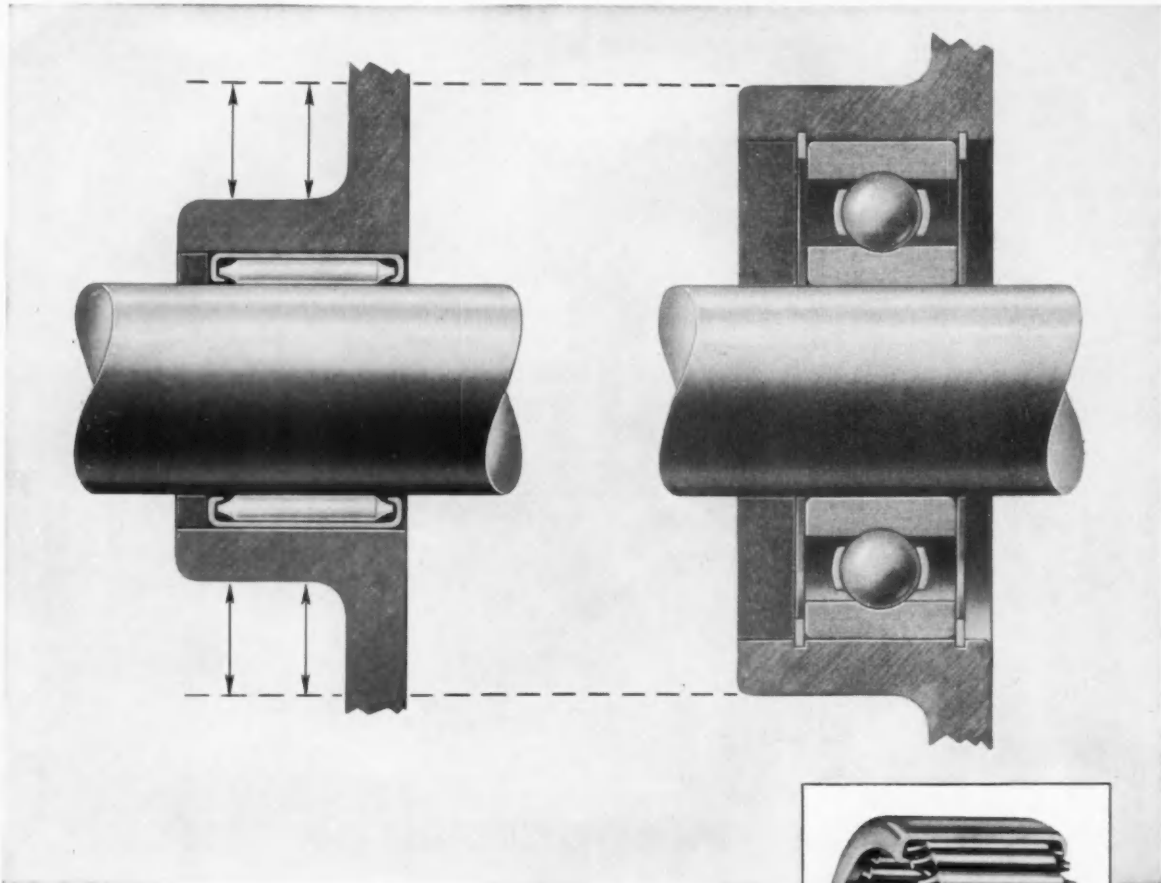
"Onan equipment is built for 100 per cent dependability, so we chose International engines when specs called for water-cooled power." Report from J. C. Hoiby, Vice President, Engineering, D. W. Onan & Sons, Inc.



UTILITY POWER

"International engines help give all four models of our earth augers fast digging action, high speeds coming out of the hole, and clean throw-off." Report from H. B. Williams, President, Hugh B. Williams Manufacturing Co.





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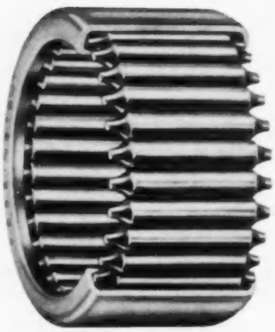

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SAE
JOURNAL

For Sake of Argument

Realism . . .

THE THOUSAND THINGS that go right every day are at least as real as the few that go wrong. A lasting concept is just as real as a thing that wears out.

How come, then, that "being realistic" is so regularly equated with emphasizing whatever is wrong, sordid or difficult? In terms of permanent values, isn't an Emerson more realistic than a Hitler? On the record, isn't even a Pollyanna at least as realistic as a Scrouge?

"Realism," says Webster, "is the presentation of nature or social life as it actually appears." Realism, in other words, is not the presentation of nature and life as it *is;* but only as it seems to be.

Perhaps realism for each of us is nature and life as we see it individually. One man will be rendered unconscious of a flower garden's beauty because the itch of a mosquito bite fills his consciousness. Another may remain conscious of the loveliness surrounding him even while rueful about a bee sting.

Concentrating constantly on what goes wrong and calling that "being realistic" is akin to arguing that the bad dream from which we awaken is real just because it scared the pants off us. It's like arguing that the relief and joy which came when we woke up is unreal.

Too often the man who preens himself as a "realist" can think of five hazards to completion of a program before he comes up with one way for possible accomplishment.

The true realist is likely to see that substance is a blend of hope and faith and of Matthew Arnold's "invincible surmise" . . . and probably is known to the world as an "idealist."

Norman G. Shidle

chips

from SAE meetings, members, and committees

COMMUNICATIONS SYSTEMS NECESSARY to operate a modern airline are almost unbelievably extensive. Teletype circuits to provide weather information to central and regional offices throughout the country are only the beginning.

United, for example, has, in addition, company teletype circuits covering 32,500 miles and connecting 225 offices. Thousands of message per day go over these circuits. Besides these facilities, United has six private telephone circuits extending from coast to coast — and from San Diego to Vancouver. These are used to exchange information, issue instructions, and conduct sizeable conference calls to resolve operating problems.

Another United facility combines the use of the private telephone line and an aeronautical radio station. Through it, direct discussions are conducted between pilots and dispatchers or meteorologists . . . from any dispatch center to any of United's flights in the United States and as far west as Honolulu.

93% OF THE HORSEPOWER AVAILABLE IN ALL PRIME MOVERS in the United States reposes in our passenger cars, trucks, buses, and motorcycles. More than 7 billion horsepower is available beneath the accelerator pedal of the gigantic vehicle fleet operating in this country.

LOW-PRESSURE PROCESS SCRAP AT CHEVROLET'S "new" aluminum foundry is ranging from 2% to 10%, depending on the complexity of the part. The cylinder head — Chevrolet's most complex casting — is now running below 10% and, according to Chevrolet's R. C. Walter, is sure to get better.

"We do not have a great amount of experience . . . and have obtained 10 yr experience in the aluminum casting business in one year," he told an SAE audience recently. "Many people in the industry using this low-pressure process get 3% scrap rate or better."

The cam gear is the only 356-alloy casting that Chevrolet fully heat treats, Chevrolet metallurgist Don Flynn told the same group. "All other low-pressure castings in 356-alloy are aged only . . . and for dimensional stability and not for strength." The cam gear heat treatment, he added, is for engineering design reasons only.

The Chevrolet aluminum foundry, Walter said, is shipping about 3,000,000 lb per month, and employs about 900 people — 350 of whom are production people.

BY 1975, WE WILL HAVE A TOTAL OF 110 MILLION VEHICLES traveling well over a trillion miles annually, according to recent projections by the Bureau of Public Roads. Will the fast-moving trend toward small and compact cars in the population rewrite these projections?

AN EMERGENCY RESCUE APPARATUS has been widely used for 10–15 years by the Armed Forces and community fire departments which uses potassium superoxide (KO_2) in a breathing canister strapped on the body. It is used with a face mask so that exhaled air is reused in a closed circuit. The KO_2 absorbs carbon dioxide and liberates oxygen.

OVER $500 MILLION worth of machine tools equipped with numerical controls will be purchased within the next five years.

TOOL MAINTENANCE COST is one of the biggest cost factors in cold extrusion. In addition, in setting up a cold extrusion job, this is one of the most difficult costs to anticipate.

Cold extrusion tools aren't like sheet metal draw dies. On draw dies, once you have produced an acceptable panel, you can feel reasonably sure that many more thousands of panels can be produced with a minimum of tool upkeep. With cold extrusion, however, an acceptable sample means nothing. The tools may break in producing anywhere from a dozen to a very few thousand pieces, and you can't anticipate this in advance. You actually have to make the parts to see what happens. If the tool life is too low, you either improve the tools or change the part design to permit better tooling until you obtain satisfactory life.

BETWEEN THE DESIGNER and the production line intervenes a process called "development" in the case of every new product. A cynic's description of this process: "Making used cars out of new cars."

COST OF ELEVATING A POUND OF MATERIAL into a 300-mile orbit about the earth has been estimated at $15,000. Newer vehicles should reduce this figure to less than $1000 per pound.

Future Car Changes

more exciting than in past

Leading car engineer specifies changes to grow from research and design currents due to flow through decade of the '60's

From talk by

Victor G. Raviolo

Ford Motor Co.

NEED FOR DIVERSITY, as well as low production costs, presents great problems to American automobile designers as they attack their 1960-1970 design programs. We must learn to produce interchangeable components in large volume . . . and to make a variety of vehicles from these components.

This has already been done to a degree. But more ingenuity is required for the future. Internal body structures have been used in common in several car lines by ourselves. But we must go much further with the mechanical components than have any of us to date.

The optimum range will be created by providing a series of shells, into which alternative powerplants can be fitted. Concentration of substantially all mechanical parts into "power-packages" will permit a high degree of interchangeability without affecting basic body shells. Further, such power-packages will not be affected as readily by styling change as are conventional chassis. Result: a high degree of automation can be justified.

The promise of minor changes and major investments means that we must be quite certain as to trends in engine and transmission designs before we are committed to a final production design.

New engines coming

Engines are the heart of the problem. Our American industry introduced a new series of engines immediately after World War II. We capitalized on what we had learned during the war about combustion, design, materials, and production techniques. Since then, we have developed and refined and exploited these engines to something near the limits of their potential.

A new series of engines is coming, probably in the mid-1960's, which will be the result of the research of the last decade. We are still not agreed on any one type and are, in fact, studying the entire spectrum of possibilities. Size and configuration almost certainly will be closely related to the package concepts described before.

Flat engines are especially favorable for rear-engine installations, but are not as adaptable to the front because of the lesser width available between the steering wheels. Front-engine packages are adaptable to the smallest size of car. However, the package concept is most difficult to apply to the larger cars because of the greater ratio of powerplant weight to total weight. The larger cars may well continue to use the conventional drive line for some time.

Materials for major engine castings will be chosen

for function and economy. Rear-engine cars require aluminum castings in order to minimize the unfavorable weight distribution, even though there is a cost penalty at this time. Aluminum will continue to be used for covers, manifolds, flywheel housings, and transmission cases. In these applications, the weight advantage can be achieved at equal or lower cost than with iron.

Lighter castings on the way

New foundry processes and techniques soon will lead to lighter and more competitive iron castings. Use of precision resin-bonded shell molds, together with automated mold assembly, results in better dimensional control. This makes possible thinner wall sections, which can be achieved in pouring by metallurgical control of iron fluidity and by design detail to ease metal flow.

Light-weight castings of iron for the major elements, such as cylinder block and head — together with judicious use of aluminum for covers and manifolds — will result in total engine weight very near the weight of an all-aluminum engine. This will be done at a cost substantially lower than that of an aluminum engine. Further, we thus avoid all the structural, thermal, and wear problems that occur with aluminum.

Higher-strength steels soon

Ford is also working with high-strength steels in its Scientific Laboratory. In the past, ultra-high-strength steels were known as laboratory curiosities. They have been very expensive and, characteristically, too brittle for most applications. We have now achieved steels of 400,000 to 500,000 psi tensile strength with elongations of 7½%.

Preliminary studies indicate that these steels can be made at reasonable cost in large volume production. We are not yet certain of the possibilities of using these steels for working parts, but we are confident they will find a place in automotive design.

Growth of the world market for automobiles will have a direct and marked effect on fuel cost and utilization. Our American customer has had only a minor regard for economy of operation because of low-priced fuel. However, fuel prices certainly will rise as the world demand for fuel increases. Then, these rising prices will be reflected in smaller average vehicle size and lower average horsepower. Many customers who now prefer a large used car will be induced to buy a new small car.

New energy sources sought

There will be a continuation of the search for new energy sources, such as nuclear energy or fuel cells. The fuel cell in particular is intriguing to us, despite its present cost, weight, and size. The promise of efficiency of 85% or better is exciting when compared to the reciprocating engine, which is limited by the Carnot-cycle efficiency and other practical factors to less than half of that value.

Nuclear energy probably will not be applicable directly to ground vehicles, but it may be a secondary source. For example, a controlled fusion process could well be the source of low-cost electrical and heat energy, which could, in turn, be used by chemical plants to make fuels for fuel cells.

New engines for ground vehicles

Among the more conventional powerplants are three types that include turbines in the final drive. These are the gas turbine, the free-piston gasifier plus turbine, and the compound engine.

The gas turbine promises very high power-to-weight ratio at the cost of increased fuel consumption. The classic single-spool machine with regenerator is reasonably efficient within a narrow range of speed and load. Ford is now well along with a new arrangement. This consists of a small compressor-turbine combination supercharged by a low-pressure compressor resulting in a high overall pressure machine. It includes intercooling between the compressor stages, a reheat burner between turbine stages, and stationary exhaust heat exchangers.

Component development is complete, and the assembled engine is now on bench test. This will be followed by vehicle installation this year.

The fuel consumption is within the diesel range and with a flat curve. That is, if we plot specific fuel at full or part load, we get a curve below many diesels and nearly as low as the best.

Materials and production techniques have been major problems. We have successfully developed iron-aluminum alloys which are ductile and can replace stainless steels for many applications. We also have developed such techniques as forging all the individual turbine blades into the hub in one blow, thereby eliminating fine machining and fitting.

As a result, we believe this turbine will be competitive in cost with low-volume, high-quality diesels. Being competitive in first cost and in operating economy, the turbine's great advantage would lie in lower weight (one-third that of a typical diesel) and in greater life (two to three times that of a typical diesel). There is little promise that costs equal to automobile gasoline engine costs can be achieved.

Some time ago, Ford designed and developed a free-piston gasifier and turbine combination and installed one in a tractor. It was a technical success, but we found it did not offer enough advantages to create a new market demand. Cost studies were made, and it was determined that the engine could be produced at a cost slightly less than a tractor diesel but not as low as a gasoline engine. The prime limitation is the low frequency (corresponding to low rpm in diesels) that results in low power-to-weight ratio. This in turn inhibits broad application to ground vehicles other than tractors.

The compound engine is theoretically the most desirable and practically the least desirable vehicle engine. The theoretical cycle indicates the highest efficiency, but in cost and complications, the engine includes the worst features of both piston and turbine engines.

Conventional piston engines will continue to power most vehicles in the next decade. These may well include some major developments in combustion in either the gasoline or diesel version.

New diesel promises

The diesel offers new promise as a result of the very aggressive research of the past few years. The leading laboratories around the world are working on high-speed diesels, intended for maximum oper-

ating speeds of more than 4000 rpm. The problems of injection and combustion have been resolved in the laboratory, and will soon be reduced to production practice.

The conversion of a heavy-duty truck from gasoline to diesel power is very costly because of the lower maximum speed and greater weight of the diesel. Higher speed means a higher power-to-weight ratio, but also means that the same transmission axle and running gear can be used for gasoline or diesel. The cost of conversion can be reduced to about one-fourth of former costs.

The economics of diesel operation change entirely with this development. Instead of a truck operator needing two years or more to recover the incremental capital cost of the diesel, he could recover the new incremental conversion cost in some six to nine months. This will create a new market for diesels in taxicab, delivery truck, and farm truck usage.

Diesels for passenger cars

The availability of light-weight diesels will make it possible to offer them as optional powerplants for passenger cars. The extensive use of diesels for passenger cars will depend on local fuel prices and taxes. In the United States, it will be difficult for the private owner (driving an average 10,000 miles per year) to recover the added cost.

Stratified-charge engines promising

The gasoline engines also are likely to include some new developments in combustion. All these can be classified as stratified-charge engines.

There are a number of forms such engines can take. They may use precombustion chambers supplied with a stoichiometric mixture, which will be spark ignited and, in turn, will fire a lean mixture in the main chamber. They may use a stratified charge in the main chamber by control of airflow and fuel flow. In either case, they almost certainly will use fuel injection and may well run with an open throttle, except for very low speed and load. There must be a means for separating the normal firing charge from the very lean mixture that can be burned only with high-energy ignition. These engines probably will run with excess air.

The stratified-charge engine is the most promising development for passenger-car engines. Potential fuel economy is projected for certain of these arrangements at more than a 50% improvement in miles per gallon. Development of such engines probably will not be fast enough to permit them to be introduced in the mid-1960's. However, some manufacturers surely will pursue this development aggressively and may succeed before the end of the decade.

Improved reliability forecast

Along with developments in engines, materials, and fuels, we also will see important developments in the rest of the car. Improved reliability, durability, and safety continue to be the common goal, as well as lower initial and operating costs.

The increasing cost of service justifies additional cost in the original build. We have been reducing the number of points on the car to be greased or oiled, and we will soon achieve a chassis that does not require lubrication. Some points will be lubricated for life at assembly; some will use lubricationless bearings of plastics or slippery alloys, such as iron-graphite. We also are working toward axles and transmissions that are sealed at assembly and normally would not be serviced until a major overhaul. Cooling systems also will be sealed off at assembly. Better sealing and protection will be required to make this possible, as well as better original-fill lubricants.

Structural design of frame and body or of integrated body-frame cars is making progress. As we gain experience with integrated structures, we are learning to use metal more effectively to increase torsional and bending rigidity while reducing total weight. The frame-and-body car is likely to continue for some time, especially in the car lines with many body types. The knowledge gained from integrated structures also is effective with frame and body, and more new frame types will appear. The separate frame and body will be designed as a compound structure to work as an integrated structure after assembly, in contrast to the classic concept of the frame as a platform for a floating, rubber-mounted body.

Aerodynamic design studied

The development of high-speed highways makes it possible for low-powered cars to maintain high

AUTHOR VICTOR G. RAVIOLO is executive director of Ford Motor Co.'s engineering staff.

For many years he has been intimately connected with the forerunners of all the engineering developments he talks about in this article. He is currently in the middle of the swift-flowing stream of automobile design and development as it rushes into the decade of the '60's. Only recently, he returned from a European trip during which he discussed future automobile developments with leading engineers of France, England, Germany, and other European manufacturing countries.

RAVIOLO

In this article, he documents item by item, the background for his conviction that:

"The automobile, now in its second half-century of existence, has not reached the end of its development. In fact, the future offers the promise of more exciting changes than the past."

past . . . continued

speeds for long periods of time. This will tend to reemphasize aerodynamic design. The obvious advantage to be gained is the reduction of drag, leaving more power available for acceleration in passing maneuvers and also making better fuel economy possible. Less obvious is the control of lift and transverse forces in order to maintain traction and stability at high speed.

There was a time when aerodynamic design was not acceptable to the customer because of its radical appearance. People today are more sophisticated about form and function and are more ready to accept a new form if it is furnished and trimmed attractively. The most interesting aspect of our recent wind tunnel experiments is better knowledge of how much can be gained aerodynamically without noticeably affecting appearance.

Automatic controls?

The increase in average highway speeds has led some to believe that automatic controls will be needed to overcome the driver's deficiencies. Such controls have been shown in various forms and are possible to install, if we are willing to accept the high cost. However, it cannot properly be assumed that the "black box" will do the job better than the human being. Many years of study and experimentation in this field, indicate clearly the limitations of automatic sensing and control, in contrast to the enormous amount of information received, analyzed, and stored away for use by the human driver.

We can, and must, do all we can to help the driver. One desired goal is to fit controls better to the human being. Also, we can give the driver more information by:

1. Improving his vision by greater use of clear glass area and by better night lighting.

2. Extending the limits of his senses . . . as, for example, by providing a device to warn against excessive rate of closure — in time to permit safe deceleration to avoid the rear-end collisions so prevelant on superhighways.

3. Providing changeable signs and short-range radio to give him more information on road surface, weather conditions, and dangerous obstructions ahead.

Conclusions

All of which adds up to the fact that automobile development trends are leading us into an era in which the "universal car" will be less important . . . and in which we will see a variety of specialized vehicles developed.

The piston engine will be our major power source for some time, but will include some notable improvements. New materials and new structures will provide increased utility and lower cost.

The automobile, now well into its second half-century of existence, has not reached the end of its development. In fact, the future offers the promise of more exciting changes than the past.

Filtration now vital for hydraulic systems

Based on paper by
Legrand E. Terry
Vickers, Inc.

THE HYDRAULIC system of today is a far cry from that of ten years ago. And the advances in design make it imperative to use filtration to get overall high performance. Nine factors spell out this need:

1. Horsepower has been increased as much as 100% to get more useful work. This puts greater demand on the hydraulic circuit and requires that it perform more efficiently.

2. Pump speeds have been doubled and may run as high as 2400 rpm. Higher speeds mean more wear, more contaminants. Without filtration the wear rate is increased.

3. Pump pressures have risen as much as 100% to attain well over 2000 psi. At such pressures, contaminants can scratch sealing surfaces and lower efficiency.

4. Reservoirs have been reduced in size. Oil that once circulated completely every 2–3 min may now circulate five times in a single minute. This gives contaminants a chance to do damage at a faster rate.

5. Oil temperatures once stabilized at 120 F may now reach 240 F. This increases rate of oxidation, adding to sludge production.

6. Mating parts have closer fits. Clearances of 0.0002 in. are not uncommon. But a 25-micron particle is 0.001 in. in diameter. When the size of particles circulating in the system is greater than clearance between parts, these openings act as expensive filters.

7. Components once required to be service-free for 1000–1500 hr are now expected to run 3000–4000 hr. The longer exposure to contaminants means more wear.

8. Down-time costs have risen many times. Filtration can often save its cost in the prevention of down-time.

9. The lack of direct manual overrides on most complex hydraulic installations increases the vehicle operator's dependence on the reliability of the control components. Removal of contaminants insures greater reliability.

To Order Paper No. 223C . . . from which material for this article was drawn, see p. 6.

struggles in the history of the automobile industry.

Contents of Article

1961 Passenger-Car Engineering Trends

ENGINEERING of American cars is changing just as rapidly as the passenger-car market is changing. In many respects, today's engineering changes are as unpredictable as today's market changes.

Walter G. Patton
Engineering Editor, SAE Journal

(Written at the request of and with the cooperation of the SAE Passenger-Car Activity Committee and the SAE Body Activity Committee)

AT LEAST two auto plants are planning to assemble BOTH body-and-frame and unitized bodies on the SAME assembly line during 1961. If any proof is needed demonstrating the tremendous changes now taking place in the automobile industry, here it is! Let's look at some engineering trends that appeared recently to be well established:

• Who would have predicted a few years ago that the entire U. S. automobile industry — except the highest price class — would be **competing across the board by 1961?** Yet this is the situation today.

• As recently as two years ago, it appeared the transmission would be moved to the rear axle. This would permit a nearly flat floor. Such a move is no longer a certainty. Enough progress has been made recently in reducing the hump in the floor so that the transaxle, if it comes, will probably come slowly and to only a limited number of cars. It is significant that no substantial amount of new tooling for the transaxle was bought for the 1961 cars.

• A few years ago, 6-cyl engines were supposed to be fading out rapidly. According to Ward's Automotive Reports, of cars built during the 1960 model year, 42.4% had 6-cyl engines: As recently as 1957, the 6-cyl engine accounted for only 17.3%. This year, a 4-cyl engine will be introduced by Pontiac. Built on the same line as the Pontiac V-8, introduction of this engine poses some riddles, principally economic, that are perplexing to say the least. Pontiac's 4-cyl engine is almost certain to get top engineering and management attention during 1961. Countering the 4-cyl Pontiac and the trend to 6-cyl engines, two new General Motors' compacts have 8-cyl engines.

• As recently as a year ago, aluminum engines seemed to be sweeping the U. S. industry. This year the first U. S.-built die cast passenger-car engine is being introduced by American Motors. Buick and Oldsmobile also have new aluminum engines that are semi-permanent-mold cast. Meanwhile, technological progress by iron foundries, plus new engine design concepts, have led many engineers to believe that cast iron can compete successfully with aluminum in the engine field. Here the stage seems to be set for one of the greatest competitive

struggles in the history of the automobile industry.

• For several years unitized bodies have been getting a lot of headlines. All the new compact cars have unitized bodies. Chrysler changed nearly all of its bodies over a year ago to unit construction. This year, however, three General Motors cars: Buick, Oldsmobile, and Cadillac, have new frames. Except for compacts, the Fisher Body Division of GM is holding the line on body-and-frame construction. The new Lincoln Continental is unitized, but Ford and Mercury will continue body-and-frame construction through 1961 at least.

There are many things to be considered before making major decisions affecting car body design. Not the least of these considerations is the economics involved. Some engineers argue strongly that the alleged economic advantages of unitized construction have not been realized in the larger cars and that body-and-frame construction can be just as economical in the full-size cars as the unitized design. It is also argued that body-and-frame cars can be made just as quiet as unitized bodies. Experience to date indicates that, as the wheelbase increases, unit-body cost tends to go up.

What appears to be happening to our American automobiles is that the public is demanding — and getting — smaller cars, on all fronts. The extent to which the present trend will invade the entire automobile market is not yet clear. However, these things seem reasonably certain, regardless of current shifts in the market:

1. Introduction of the smaller cars has greatly emphasized the necessity of holding down production costs.

2. In the final analysis, customer satisfaction — plus economics — will dictate the decisions about aluminum engines, unitized bodies, and the ratio of compact cars to standard cars.

Problems unlike anything seen previously by the industry will undoubtedly plague the motor industry's management during the next year. Adjusting auto plants and the labor force and designing flexibility into tooling to meet the requirements of a rapidly changing market will be among the challenging problems facing engineers and management.

Contents of Article

Trend to lightweight engines . . .

. . . is accelerating. Both new Al and new cast-iron engines show substantial weight savings. Design for efficient manufacture is a "must" today. Crankcase ventilation device is mandatory for 1961 cars in California. New compacts feature low weight per volume ratio.

NOBODY knows the total development cost of the three new aluminum engines being introduced this year (plus numerous significant refinements to other engines). However, if the facts could be determined, the sum would be in the millions.

Undoubtedly, the major development work today in passenger-car engines is directed toward design of lighter weight engines. Substitution of aluminum for cast iron in a V-8 engine may save 100 lb. The new Falcon cast-iron engine introduced by Ford last year weighed 190 lb less than the last standard Ford 6-cyl cast-iron engine having the same horsepower.

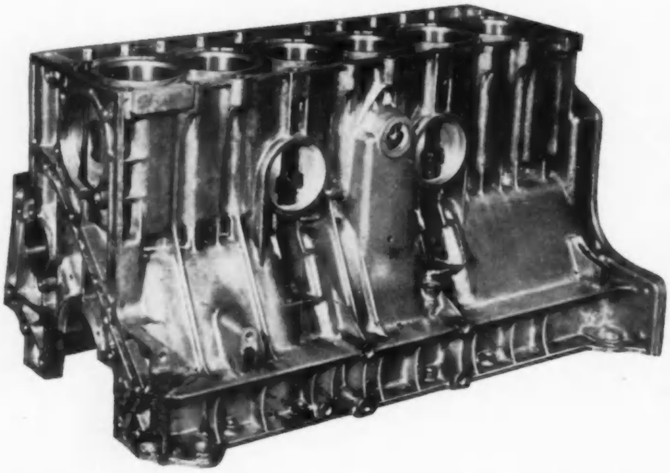
Another trend that is much in evidence at the moment is designing engines for efficient manufacture. The growing number of die castings used on today's engines reflects this trend.

Under the new competitive conditions, practically every car manufacturer is now offering (1) an economy engine designed to operate on standard fuel and (2) a range of engines that offer the customer optimum economy or maximum performance. Matched with a choice of transmissions and axles, the customer may buy just about any combination of economy and performance that suits his personal taste. This practice is now virtually industry wide.

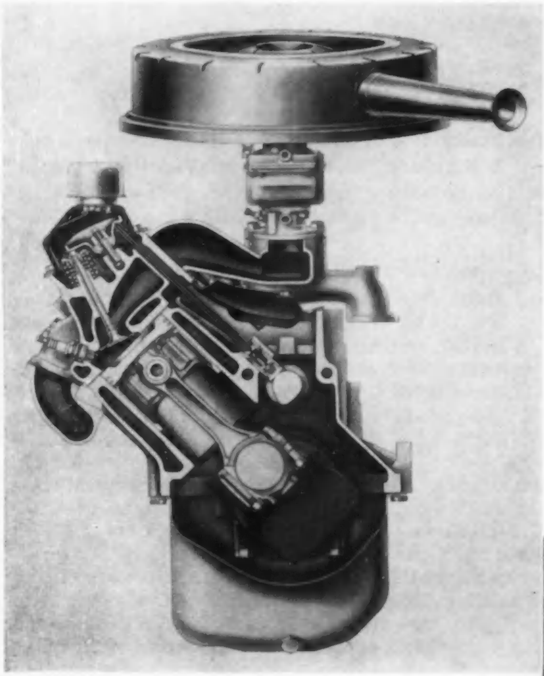
1961 will be noteworthy for the introduction of positive crankcase ventilation (mandatory in California.)

Another interesting development will be the introduction by Lincoln Continental of an engine that has seven different parts, each selectively fitted. The new Lincoln Continental powerplants are broken in for the customer by running for 3 hr on test stands at 3500 rpm prior to installation in the car.

With few exceptions, compression ratios and horsepower ratings have remained about the same. The big change has been that in a typical "super-compact," engine displacement to car weight ratio has been increased substantially compared with a 1961 standard model. The availability of special kits to boost compact car performance is further proof of the



AMERICAN MOTORS has the first die-cast aluminum engine. Shown here is the die casting.



PONTIAC TEMPEST 4-cyl in-line cast-iron engine is a single bank of the 8-cyl cast-iron V-8 used on standard Pontiac cars.

growing importance of a powerful engine in the typical U. S. passenger car.

This year will see the introduction of another inclined engine — by Pontiac.

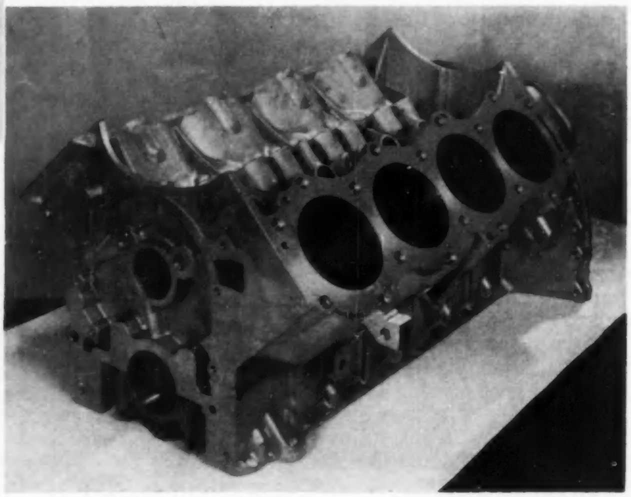
Problems of valve timing and engine mounts are again getting increased attention.

More detailed discussions of the major engine developments follow:

If aluminum is to become the engine material of the future for U. S. passenger cars (and many engineers think it will be), introduction of the first die-cast aluminum engine this year by American Motors can only be described as a great milestone in automotive history. Development work on this engine, a cooperative effort by American Motors and the Doehler Jarvis Division, National Lead Co., has been continuing for more than six years.

The new Rambler 6-cyl engine represents an entirely new achievement — a passenger-car engine designed for die casting. Numerous struts and stiffeners were added to the engine block following test studies. Changes in design had to be made, sometimes just to permit casting in a die. The new engine has a drop-center crankcase. Water passages and intake manifold are changed as compared with the predecessor cast iron engine. A full-flow filter is specified.

Almost the only design detail unchanged on the Rambler aluminum engine is the bore and stroke.



OLDS AND BUICK V-8 aluminum engine block is semi-permanent mold cast by GM Central Foundry Division. Cylinder liners are cast iron, integrally cast.

The prototype of the present engine was completed early in 1958. A sand-cast engine was built first and tested. Many of the present casting techniques are based on experience with the sand-cast prototypes. Two prototypes, each sand cast prior to permanent-mold casting, were completed before extensive field testing of the present engine was started.

The finished die for casting the new Rambler engine has 208 pieces. More than a dozen slides are used to draw out the cores.

The alloy used is Doehler Jarvis Sl, containing 12% Si.

Advantages claimed for a die cast aluminum engine include light weight, high volume production per sq ft of floor space and clean internal passages that are entirely free from dirt and sand. This latter advantage may someday become very important, many engineers believe.

The new Rambler engine is the largest die casting ever produced in this country, weighing 52 lb. A saving of 80 lb was made possible by the changeover to aluminum.

An important part of the development work centered around the use of Zansman stress strips for testing stress concentrations, both statically and dynamically. A well-established aircraft technique, this method has not been widely used heretofore by the automobile industry.

Displacement of the new aluminum 6-cyl engine is 195.6 cu in. Compression ratio is 8.7 to 1.

Cast iron liners have a maximum thickness of 0.093 after machining. The cylinder head is made of cast iron.

The new engine has hydraulic valve lifters, 100% counter-balanced crankshaft, an oil pump designed to eliminate hydraulic lock, and an aluminum water pump. A single throat Holley carburetor is used on manual shift cars; a twin throat Carter carburetor is specified for automatic transmission cars.

The crankcase skirt was added primarily to increase the structural rigidity of the block.[1]

The powerplant for the compact Pontiac Tempest is a 195 cu in., 45-deg inclined, short-stroke 4-cyl engine. The Tempest is the first engine-in-the-front, transmission-in-the-rear car offered by an American manufacturer.

The engine is the modified right bank of the standard Pontiac V-8 engine. It will be produced on the same highly automated line, using the same tools as for the standard Pontiac engine. Fixtures have been modified to take both engines.

To achieve smoothness in this 4-cyl engine, Pontiac engineers have taken many interesting steps, including balancing the crankshaft to 0.50 in.-oz. There are four integrally cast crankshaft counterweights. Engine mounts are unusually flexible in front, permitting a wide latitude of engine movement. However, rigid attachment to the torque tube appears to exercise a desirable restraint on engine movement. The torque reaction is taken at the rear suspension mounts. Pontiac engineers say recent progress in the design of engine mounts and their unique torque tube arrangement have contributed importantly to the satisfactory performance of the 4-cyl Tempest engine. The fact that the driveshaft is small also contributes to the remarkably low stress on the driveline.[1]

Buick's first V-8 aluminum engine has been designed to give outstanding output and economy for a lightweight engine. In addition to an aluminum block and head, light metal is used for the intake manifold, rocker arms, oil pump, timing chain cover, water pump, fuel pump, and distributor holder.

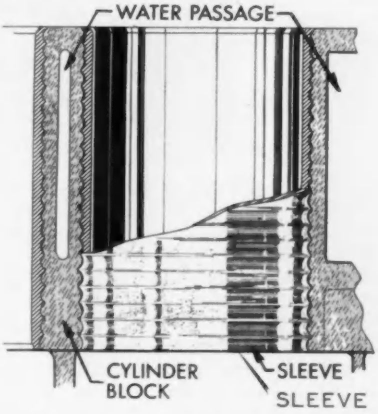
Displacement is 215 cu in. Stroke is 2.80 in. and the bore is 3.50 in. Compression ratio is 8.8/1. The Buick 4000 engine develops 155 maximum bhp at 4400 rpm.

The engine pan rail has been brought below the crankshaft centerline to give maximum strength and rigidity to the block. Blocks and heads are semi-permanent mold cast by General Motors Central Foundry Division. A cast Armasteel crankshaft is used.

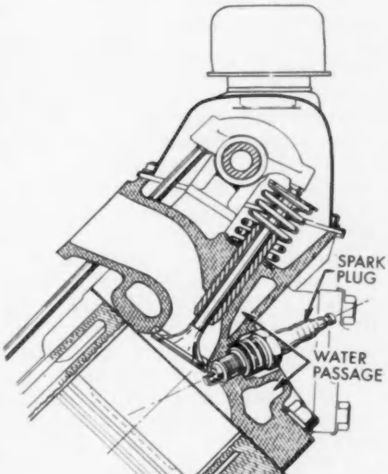
Centrifugally cast alloy iron sleeves are cast integrally with the block. Valve-seat inserts and valve-guide inserts are used. The intake manifold, similar in design to the present Buick V-8, is cast aluminum.

A slight depression in the piston forms part of the combustion chamber. The round combustion area in the head is relatively shallow. Spark plugs are located approximately in the center of the head.

An outstanding feature of the Buick 4000 aluminum V-8 engine is combining the timing chain cover, oil pump cover, and the base for the oil filter in a single die-cast subassembly. The oil pump cover

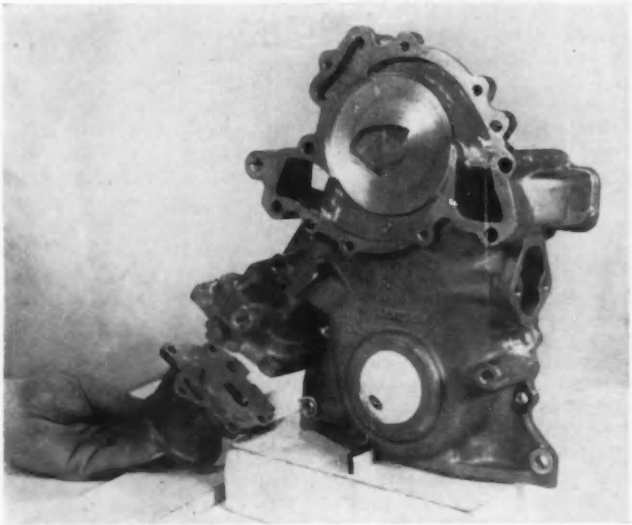


BUICK semi-permanent mold cast-aluminum cylinder block has integral cast-iron cylinder sleeves.



SLIGHT DEPRESSION in the piston forms part of the combustion chamber on Buick 215 cu in. aluminum engine. Spark plugs are located nearly in the center of the chamber.

[1] Complete details will be given in a paper to be presented at the 1961 SAE International Congress and Exposition of Automotive Engineering, Detroit.



SINGLE DIE CASTING combines timing chain cover, oil pump cover, and base for oil filter on Buick models, helps save weight and cuts manufacturing cost.

serves as the base for the oil filter. In addition to elimination of assembly costs, a substantial reduction in manufacturing cost and weight of the engine has been accomplished by this unusual design.

By the use of lightweight pistons and connecting rods, the Buick 4000 engine has also made possible a reduction in crankshaft weight. The crankshaft, incidentally, requires no metal removal from the cheeks or the outside surface of the counterweights. Except for the bearing surfaces and the ends, no machining is required on the crankshaft. Counterweights were designed to take out the inherent couple in a V-8 engine; this design also permits relatively constant clearance with respect to the pistons.[1]

The Oldsmobile Rockette engine used in the F-85 is an Olds design. Aluminum blocks and heads are furnished by GM's Central Foundry Division. Machined blocks are supplied by Buick. All other machining and all assembly operations are performed at Lansing.

The 215 cu in. F-85 engine has a compression ratio of 8.75/1. Bore is 3.5 in. and stroke 2.8 in.

Combustion chamber is wedge-shaped, similar to the Rocket engine. The new aluminum engine has 12 main water passages.

Olds' F-85 air cleaner encloses the carburetor but major adjustments can be made from the outside. The new design provides better protection against weather and improves silencing.

Olds is using six bolts per cylinder to fasten down the semi-permanent-mold cast-aluminum head.

The alloy used for all major components is Aluminum 356. This includes the cylinder block and head, intake manifold, clutch housing, and water pump. Cast iron is specified for cylinder liners, valve guides, main bearing caps, and exhaust manifold.

This is the first Oldmobile in modern times to have a cast crankshaft. Forged crankshafts are used on other Olds engines.[1]

A 6-cyl overhead-valve cast-iron engine powers the Dodge Lancer. Displacement is 170 cu in. An optional engine of similar design displaces 225 cu in. Both engines are inclined at an angle of 30 deg. Compression ratio is 8.2/1.

A three-point engine mounting on the Lancer utilizes the mass of the engine as a dynamic vibration absorber. The mountings are tuned to the car structure so that suspension-excited vibrations are damped out by oppositely phased oscillations of the engine. The mountings employ large rubber-steel sandwiches.

Lincoln Continental engine improvements include a quieter single coil, constant-pitch valve springs, an improved distributor with heavy-duty points, a carburetor bypass system, stepped-diameter camshaft journals, and a camshaft drive sprocket having nylon teeth.

Filtered air is fed to the choke to prevent dirt accumulation in the choke housing.

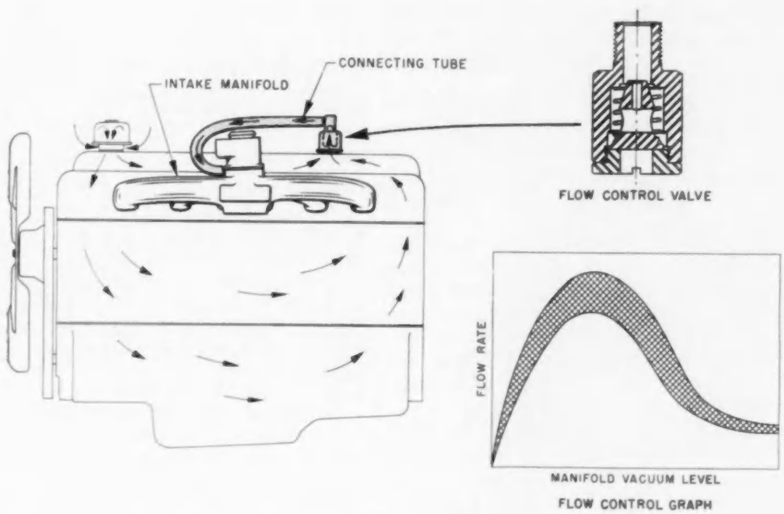
Lincoln Continental is also using a vapor-separating unit on all air conditioned cars to eliminate vapor lock. The vapor separator bleeds off any fuel vapors before they can enter the carburetor. A float needle and seat closes the bleed-off orifice when the proper amount of fuel is in the bowl.

Lincoln Continental has a special "Select Fits" program for its 1961 engine. Select fits will be used on main bearings, main journals, tappet bores, intake and exhaust valves, connecting-rod bore, and bearings. In addition, many other tolerances have been cut in half.

Brakes, filter, engine idle, and other items normally requiring adjustment by the dealer have been designed to avoid early service. Engines are run 3 hr at 3500 rpm for break-in before the car is turned over to the dealer. All cars are given a 12-mile road test at the factory. These and other steps are being taken to avoid early dealer service. Customer service is unnecessary on the Continental up to 6000 miles, Lincoln engineers are suggesting this year.

The Lincoln Continental has low friction valve rotators made by Eaton Mfg. Co. operating at idle speeds instead of waiting until the usual 1800 rpm have been reached. This avoids hot spots at all running speeds and promotes longer valve life, it is argued.

A positive crankcase ventilating system will be installed on all Chrysler (and other cars) cars intended for sale in California. Chrysler (and others) route crankcase vapors into the intake manifold, from which they pass into the cylinders and are burned. This replaces the conventional system used on standard cars and consists of a special carburetor, a spring-loaded valve mounted in the small steel cylinder on the rocker arm cover through which crankcase gases are normally vented, and a flexible tube connecting the valve and carburetor. The specially calibrated carburetor contains a fitting just below the throttle blades into which crankcase vapors are drawn by the suction in the intake manifold. Since there is flow



POSITIVE CRANKCASE VENTILATION SYSTEM is installed on all cars shipped to California starting in 1961. Crankcase vapors are taken into the intake manifold, as shown here in the system used on the Dodge Lancer.

through the breather system all the time the engine is running, better crankcase ventilation is obtained at idle and low speeds. Essentially the same method is used by all car producers in the industry.

An increase in the stroke and other refinements have resulted in a power increase of 18% in the Falcon 170 cu in. 6-cyl engine (compared with the 144 cu in. engine). Increase in weight is only 2%. Included in the engineering changes are a heavier crankshaft, new slipper pistons, new cylinder head, larger intake valves, new bearings, and a 15-in. fan. The carburetor is also new; a larger choke plate offers improved cold engine performance.

Compression ratio of the 6-cyl Chrysler engine has been reduced during the 1960 run from 8.5 to 8.2. A cast-iron manifold replaces an aluminum manifold. Valve timing on the 225 cu in. six has been advanced 8 deg by re-indexing the camshaft. Two-stage stepup jets have been extended in usage to include all V-8 engines.

Chrysler carburetor float needles are tipped with high-grade synthetic rubber. The rubber tip makes a resilient and positive seal between the needle valve and its seat, virtually eliminating carburetor flooding caused by particles of dirt between the needle valve and seat. If dirt particles are present, they are temporarily embedded in the soft rubber so that the valve closes tightly with no leakage paths.

Displacement of Corvair has been increased to 145 cu in. from 140 cu in. Stroke remains at 2.60 cu in. Greater torque has made possible introduction of a new economy axle.

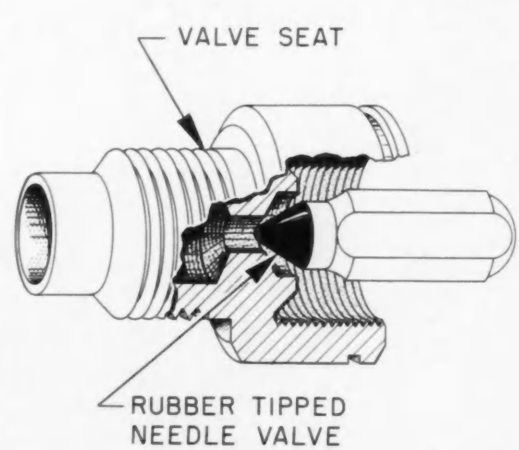
The air induction system has been simplified. Gasoline metered to the venturi cluster is more accurately proportioned to available air volume. A new engine temperature gage has been installed in the cylinder head, replacing an oil temperature sending unit. The high-performance engine horsepower is increased to 98 at 4600 rpm.

Cadillac engine position has been lowered, contributing to lowering of the floor of the car. Flywheel size has been reduced and the new oil pan is shallower. The full-flow filter is retained. A polyurethane element replaces a paper element in the air cleaner. The 3 × 2 carburetor has been dropped.

Rambler American for 1961 exemplifies a growing trend in U. S. passenger-car engines. The 1961 Rambler American, for example, offering two engines and three transmissions and a choice of two axle ratios, can now provide a wide range of engine-transmission-axle combinations. Thus, a choice of economy or performance, or a combination of the two can be offered to the prospective buyer.

The Comet will be available with either the 144.3 cu in. or an optional 170 cu in. in the 6-cyl line.

The cylinder head has a new



RUBBER-TIPPED CARBURETOR NEEDLE VALVE virtually eliminates carburetor flooding caused by particles of dirt between needle valve and seat of Chrysler cars.

configuration and intake valves are larger. The larger capacity carburetor has revised venturi bore and calibration. The engine has new main bearings and a 15-in. diameter fan.

Mercury is offering a 6-cyl engine for the first time in its history. The new Mercury engine has a more rigid mounting for the vacuum booster pump, new slipper-type pistons with a dish-type dome, and dual valve springs with secondary spring damping wound in the opposite direction to the valve spring.

Pontiac standard engines will use sintered valve rocker arm balls, replacing steel. Bearing area is larger. Also, valves and push-rods are shorter and their weight has been reduced.

New cast-iron cylinder heads are also lighter in weight.

Displacement of the Olds Dynamic 88 Rocket engine has been increased from 371 cu in. to 394 cu in. This engine operates on regular-grade gasoline.

A new engine for the Super 88 and 98, with a 4-barrel carburetor, has a revised induction system, including a new camshaft. Compression ratio has been increased to 10.0/1.

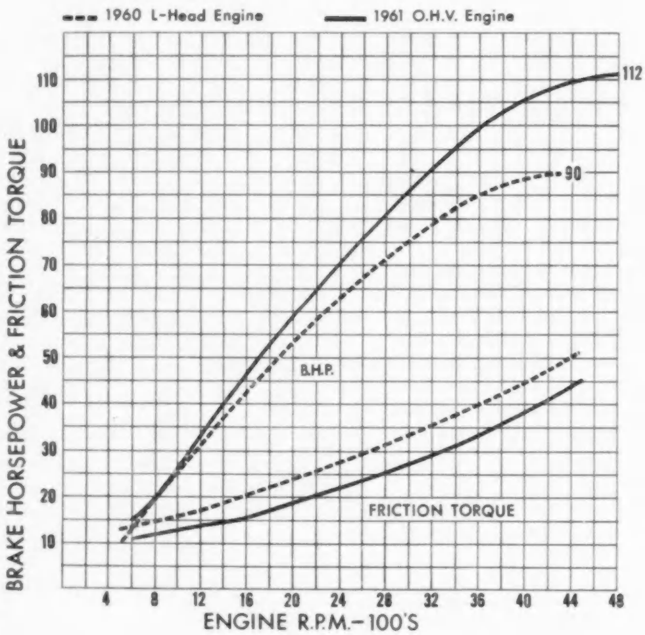
Studebaker-Packard's new 6-cyl 170 cu in. overhead valve engine develops 112 hp at 4500 rpm. This represents a substantial increase in horsepower and a reduction in friction torque over the previous S-P 6-cyl L-head engine. Compression ratio is 8.5/1.

Among the new design features of the engine are (1) a ram-type manifold with unusually large passages in the head and throat, (2) kidney-shaped combustion chamber, (3) a new camshaft with a long-ramp, low-acceleration cam, and (4) larger valves. The long ramp picks up valve clearance more slowly and reduces noise. The low-acceleration cam permits the use of relatively light-weight valve springs, lengthening the parts involved.

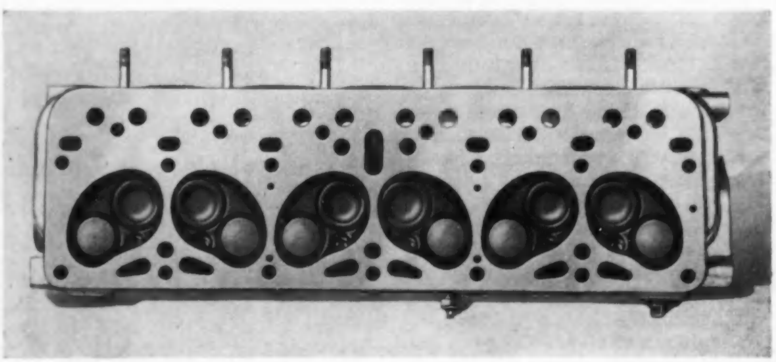
Inlet ports measure 1.875 in., a 46% increase over the previous powerplant. Passages in the head and throat are 55% larger.

A staggered valve arrangement is made possible by the kidney-shaped combustion chamber. The engine has a fully counterweighted crankshaft.

In designing the new engine, S-P engineers paid particular attention to weight savings as well as to economical tooling. For example: the bore spacing of the new engine is identical with that of the 1960 engine. The crankshaft centerline is also the same.



STUDEBAKER-PACKARD's new 6-cyl overhead-valve engine shows a substantial increase in output and reduced friction torque, compared with the 90-hp L-head engine previously used.



INLET PORTS of new Studebaker Lark 6-cyl overhead-valve engine measure 1.875 in. An increase of 46% in port area has been achieved, compared with previous L-head 6-cyl engine.

Transmission and drive-line design changes . . .

. . . are playing a major role in the successful move toward a flatter floor. Buick, Oldsmobile, and Pontiac have new transmissions. Pontiac's flexible propeller shaft is the first of its kind. Buick, Olds, and Lincoln introduce constant-velocity drive lines. Chrysler offers a new, heavy duty manual transmission.

BUICK 4000 series for 1961 is available with the first U. S. Dual-Path torque flow type of transmission using a converter. The new unit is unique in its use of an automatic clutching device that allows engine torque in direct drive to follow two parallel paths — one hydraulic, the other mechanical.

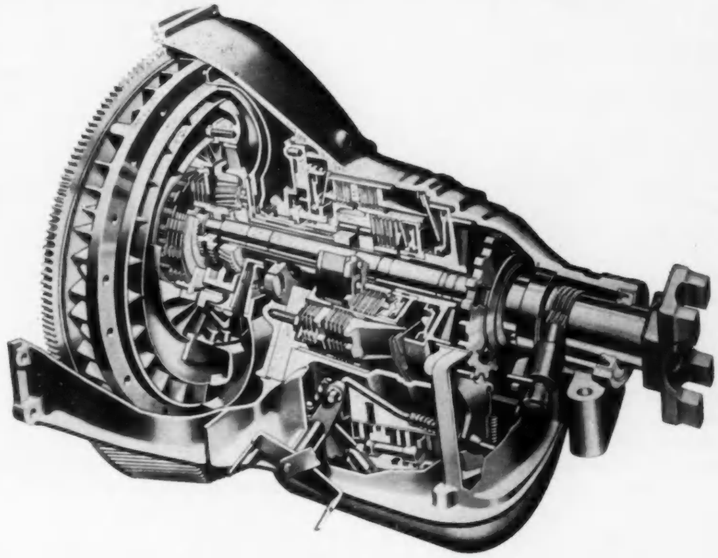
The hydraulic path is from engine converter pump to turbine to planetary gear set to output shaft. The mechanical path is from engine to converter clutch to planetary gear set to output shaft.

Another feature of the new Buick 4000 transmission is the use of aircooling. This is a departure from previous Buick Dynaflow practice. The 1961 planetary gear arrangement is like that of the Dynaflow except for the use of an additional sun gear. In direct drive, this gear locks up to the end of the crankshaft, making possible the Dual Path or split drive. A single planetary gear takes care of all forward speeds as well as reverse. A single pump, driven off the engine, is used. A parking pawl permits transmission braking.

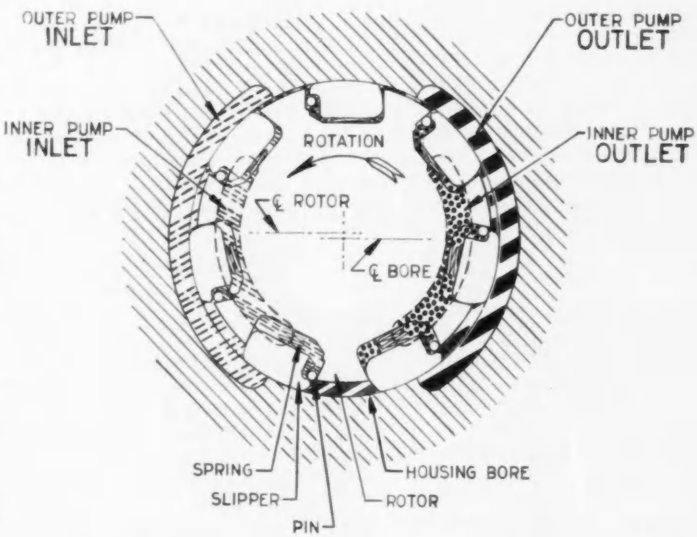
At a predetermined speed, determined by throttle opening and car speed, the converter clutch engages, obtaining direct drive, and engine input is divided — 36.6% through the mechanical path and 63.4% through the hydraulic path of the converter. A low range is provided primarily for downhill braking.

A unique slipper-type pump, produced by the Michigan Division, Thompson Ramo Wooldridge, Inc. for Buick, permits the use of a single pump to replace the two pumps used in many automatic transmissions. The new dual pump cuts out one of its pumps automatically when demands on the transmission make it desirable for a single pump to take over.

In the new Buick pump, the wide slippers, stroking radially in their rotor slots, act as pistons to provide a pumping action in addition to normal, vane-type pumping ac-



"DUAL FLOW" split-torque transmission for Buick Special is aircooled. Cooling air enters ports in the engine block and flows downward through holes in flywheels to converter pump housing. It is pumped radially along converter pump vanes by centrifugal action and out through two louvered holes in bottom cover.



SLIPPER-TYPE PUMP designed by Thompson Ramo Wooldridge permits a single pump to replace two pumps formerly used on Buick transmission.

tion, which occurs on the outer side of the rotor between slippers.

The new design provides a large area of contact between the wide slipper and the bore, providing effective sealing and maintenance of an oil film. Because stresses are low, use of powdered metal and plastic parts is readily possible.

The wide slippers are self-aligning on the bore, making close fitting in the rotor slots unnecessary. The rotor is a driving member. It is not a support member for the vane or slipper. The relatively short height of the slipper permits the use of small pumping elements, resulting in low fluid velocities, reduced cavitation, long life, and quiet operation over a wide range, it is claimed.

Displacement of the two pumps can be proportioned as desired by changing the slipper width. One pump can be set for bypass while the other pump supplies pressure to the system. In the Buick pump, the outer pump is bypassed when a specific line pressure is attained, independent of speed. (In many transmissions the rear pump takes over at a given driveshaft speed.)

Sealing between the "inner" and "outer" pump is accomplished by floating steel pins that ride free between the rotor and the slipper. Pressure differences cause these pins to seal themselves without wedging between the slipper and the rotor, acting like check valves.

Buick is replacing its enclosed driveline on all models with a 2-piece open shaft. The shafts are connected by a spline joint which slips to provide necessary travel for the lengthening and shortening required to accommodate suspension movements.

Propeller shafts are connected to the axle and transmission by a needle-bearing Cardan joint of the separable-yoke type. The center sections are connected through the double Cardan, constant-velocity joint. Angles at both the transmission and rear axle are comparatively small; the large angle is divided evenly between the two center sections of the universal joint. The new design permits the front and rear propeller shafts to run at constant speed.

The constant-velocity joint structures comprising two single joints are mounted back-to-back and piloted for location by a ball-and-socket member. The constant-velocity feature is said to eliminate any couple forces and other disturbances caused by the rotating center joint, permitting optimum driveshaft smoothness.

The 1961 4000 series is similar to the larger Buicks except that the taper roller bearing cones are mounted on the differential case rather than to the outer race.

Pontiac's unique flexible propeller shaft is the first of its kind to appear on any car. In the Pontiac Tempest, a torque tube is mounted rigidly to the engine in front and to the transmission in the rear. The flexible propeller shaft has a flanged front end which attaches to the engine flywheel or clutch driveshaft. At the rear, the shaft drives a transmission through a solid junction.

The flexible shaft is made of heat-treated and machined alloy steel. Metal removal prior to heat-treatment and a finish grind following heat-treatment assure good surface quality of the shaft, which is shotpeened to give optimum resistance to fatigue.

Maximum torque on the shaft is reported to be 180 ft-lb. Fatigue loading of the shaft is far below its endurance limit, according to Pontiac test results. Angle of mounting is 10 deg 30 min. A ⅝-in. diameter shaft is used with an automatic transmission.

Ball bearings, lubricated and sealed for life, serve as damper bearings. These are press-fitted over plastic-lined steel half bushings. Rubber insulation encases the ball bearing, which is surrounded by a 2-piece stamped housing.

No bending of the shaft is performed prior to installation in the car. The shaft and hat-section torque tube may be attached first at either the transmission or the engine end.

The half-shell bushings or sleeves and the inner race of the damper bearings are affixed to the propeller shaft and rotate with it. The bearing assemblies are clamped to the torque tube. There is also bearing support for the driveline in the transmission extension.

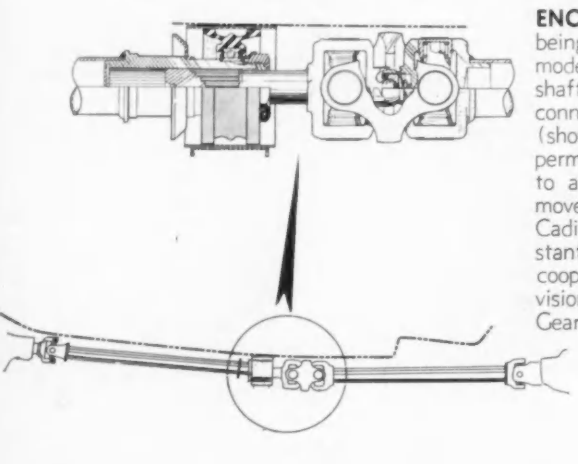
Bending of the shaft is accomplished during the installation. Tests show loading of the shaft is surprisingly low. This may be a factor in the successful tests reported up to the present time.

Pontiac Tempest will offer a conventional 3-speed synchromesh and a lightweight, aircooled 2-speed transmission with automatic upshift, depending on car speed and throttle position. In high gear, torque is split 40% mechanical and 60% converter.

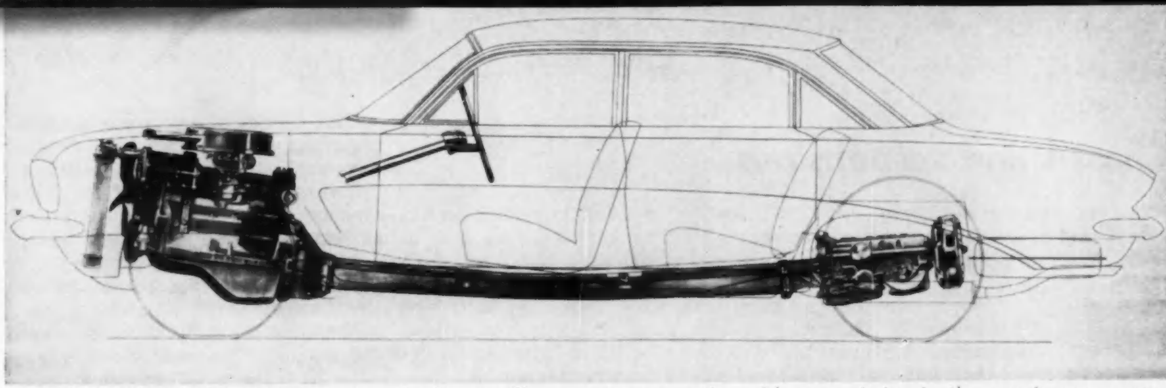
A part-throttle downshift occurs at less than 25 mph. Part-throttle downshift to low will occur if the accelerator pedal is moved to half throttle, upshifting subsequently at 45 mph. Downhill braking is provided by manual downshift.[1]

Olds F-85 is using a smaller, more compact Hydramatic unit weighing 95 lb less than the conventional Hydramatic. Outstanding feature of the compact transmission is a variable ratio first or starting gear. In effect, this permits performance of a 4-speed transmission in a 3-speed unit. The car starts with 3.64/1 ratio. This drops automatically to 3.03/1. Second gear has a ratio of 1.58/1. Later, the car moves into direct (1/1) drive.

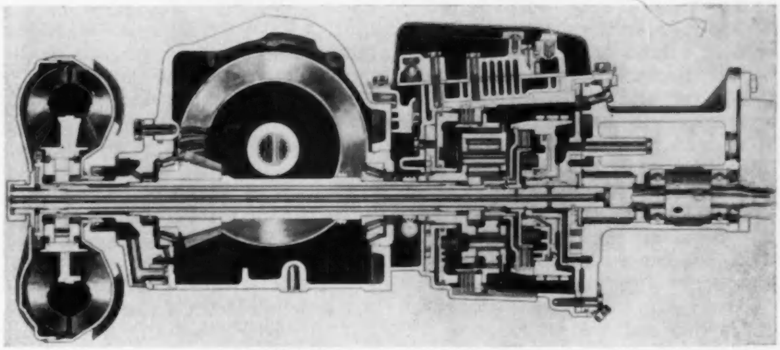
Use of the variable ratio gear has made possible elimination of an entire set of gears. In part, this is responsible for the decreased size of the unit, resulting in less intrusion of the floor space of the car. Olds will also use a constant-velocity driveline built by Saginaw Steering Gear Division.



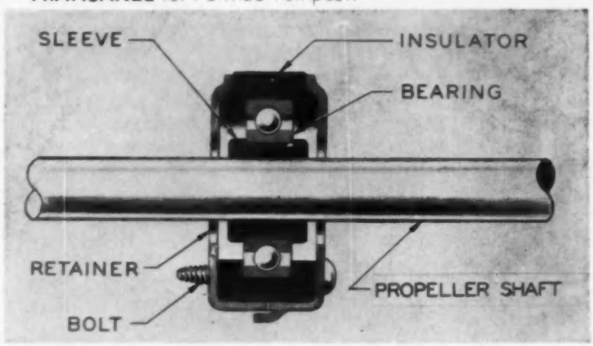
ENCLOSED DRIVE LINE is being replaced on all Buick models with a 2-piece open shaft. The new shafts are connected by a splined joint (shown here), which slips, permitting necessary travel to accommodate suspension movements. Oldsmobile and Cadillac also use this constant-velocity joint developed cooperatively by the car divisions and Saginaw Steering Gear Division.



FLEXIBLE PROPELLER SHAFT used on the Pontiac Tempest in conjunction with transmission-in-the-rear is an arrangement that is unique in the U. S. automobile. Bending of the steel is accomplished during installation.



TRANSAXLE for Pontiac Tempest.



VIBRATION AND WHIPPING of the propeller shaft are minimized on Pontiac Tempest with two bearings of type shown here.

Olds engineers have made considerable progress in reducing obstruction by the transmission-driveline tunnel. 1960 models showed a 20% reduction in tunnel intrusion of the passenger compartment; 1961 models show another 25% reduction. This has been accomplished primarily by design changes in the transmission, driveline, and frame — and not by moving the transmission to the rear of the car.

A smaller transmission, mounted at 7 deg to the engine, permits a smaller front tunnel on the new Lincoln Continental. A constant-velocity front universal joint has permitted further lowering of the tunnel. The new driveline utilizes a needle bearing slip yoke design at the coupling of the transmission output shaft to the driveshaft. The needle bearing permits quiet fore-and-aft movement at the splines, and makes possible smooth transference of engine torque through the driveline.

Lincoln Continental's needle bearing slip yoke is reported to be one of the first of its kind used by the U. S. auto industry. The new joint is particularly helpful in eliminating noise.

Chrysler Corp.'s new heavy-duty *manual* transmission is designed to meet the increasing demand for manual transmissions on large V-8's. It has torque capacity adequate for the largest Chrysler V-8 engines, and yet it is a compact unit which fits under the smaller floor pan humps of the new cars.

Gear ratios of the new transmission are 2.55 in first, 1.49 in second, 1.00 in third, and 3.34 in reverse. All gears are helical for quiet operation, and heavy-duty pin-type synchronizers are used on second and third gears. Gear center distance is 3¼ in. Ball and needle bearings are used throughout the new transmission.

The transmission case and extension are iron castings. "Closed case" construction, in which the entire case is cast as a unit, provides necessary strength and is lighter than the "open" construction used in older Chrysler transmissions.

The new heavy-duty transmission is the standard manual transmission with 361 and 383 cu in. V-8 engines, and is used on Plymouth, Dodge, DeSoto, and Chrysler models. A floor-mounted shift lever is used.

A three-speed, floor-shift manual transmission is standard on all Lancers, and a three-speed lightweight automatic with push-button control is optional equipment. Aluminum is used extensively in the automatic transmission, resulting in a weight saving of approximately 100 lb compared to the TorqueFlight automatic transmission used with V-8 engines in other Chrysler Corp. cars.

Ford's 1961 Cruise-O-Matic is 25 lb lighter than the previous model. The transmission is now controlled by vacuum rather than mechanical linkage. Transmission response is said to be improved substantially.

The 1961 Ford rear axle uses a pinion pilot bearing of smaller diameter than the previous design. This has made possible increased carrier strength and improved bearing load distribution. Ford driveline universal joints have end-relieved needle rollers, improved surface finish, and more rigid bearing cups at the flanges.

Both the transmission and the engine of the Cadillac have been lowered. A new kind of rubber support for the intermediate propeller shaft bearing gives quieter and smoother operation.

Chassis and suspensions . . .

. . . are undergoing major changes. An outstanding engineering development is permitting wheels to move slightly backward as well as upward when small obstacles are encountered. Olds, Buick, and Pontiac have new frames. Grease fittings are disappearing.

LINCOLN Continental's "Silent Strut" suspension features a new method of attaching the front suspension lower arm to a body cross-member by the use of an isolated strut. A thick rubber, bayonet-type bushing is used, which allows a slight rearward wheel displacement.

Rubber and polyurethane seals are used to retain the special lubricant provided for ball joints. The steering linkage utilizes a split nylon sleeve, eliminating the necessity of lubrication. No shims are required for wheel alignment and caster-camber adjustment has been improved.

Front and rear shock absorbers have rebound cut-off feature.

New rear springs are 60 in. long and 2½ in. wide. Method of attaching the spring at the front eye has been improved by the addition of a 2-in. diameter rubber bushing, permitting a slight rearward wheel movement on severe bumps. A sheetmetal box structure, lined with ½-in. butyl rubber, completely insulates the spring. The butyl rubber prevents metal-to-metal contact between the spring and the axle, regardless of severity of the bump.

Mercury is featuring a new "Cushion-Link" suspension. The new system provides better cushioning against road shock at all four wheels, particularly slight bumps from tar strips and small irregularities in the road.

A 2-pin shackle arrangement is used at the front pivot pin of the front suspension. The upper pivot pin provides for vertical wheel travel. The lower pivot pin permits the arm, together with the wheel, to move slightly to the rear when horizontal force is applied.

A large elliptical rubber bushing surrounds the upper pin, controlling and absorbing horizontal movement. As a result, the elliptical rubber bushing functions somewhat as a shock absorber.

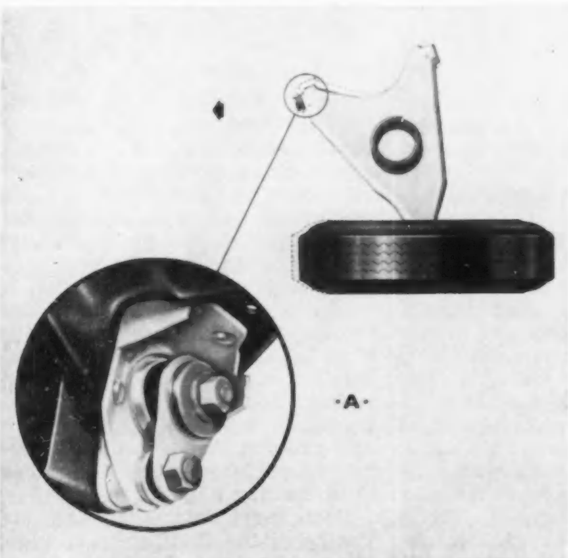
The rear suspension has a tension shackle at the front anchor of the rear spring. Horizontal movement of the wheel and spring swing the shackle about its two pivot points. Control and amount of movement are obtained by an extended arm on the shackle which is mounted in rubber.

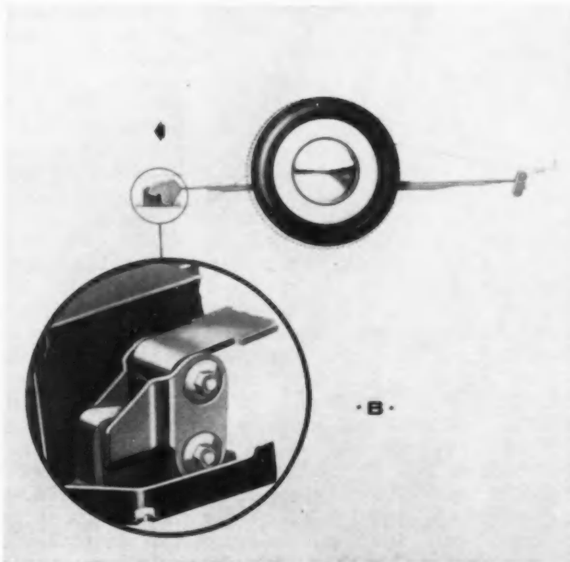
The design has these advantages: (1) all four wheels are able to recede slightly, (2) there is sensitivity to absorb very light load shocks while offering increased resistance as the shock increases.

All Ford chassis lubrication points are now pre-lubricated at the factory with a special grease containing a molybdenum disulphide base. This has made it possible to remove all grease fittings from the car. Small threaded plugs replace the usual grease fittings. Special instructions cover lubrication at 30,000 miles or two years, whichever comes first.

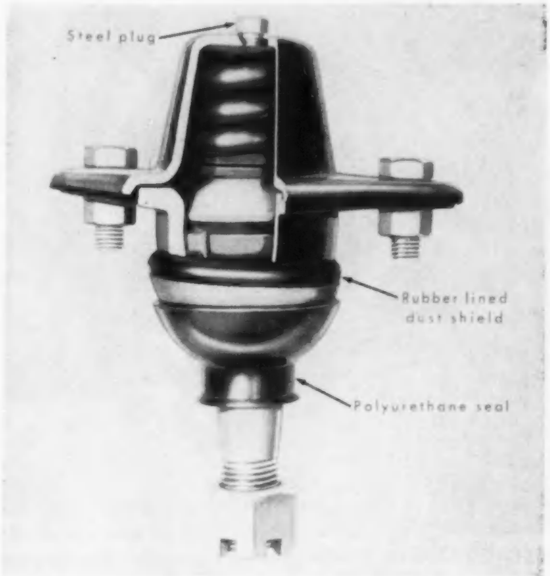
Ford has achieved a better balanced body-frame relationship. Many of the changes made have been developed following extensive computer calculations by Ford engineers. For instance, by changing the thickness of the inner frame rail and making other adjustments, Ford is able to make more effective use of the frame as a filter and as a damper. Body and engine mounts have been redesigned. Additional bracing has been added as required. A new butyl puck provides more effective insulation of the body from the chassis.

Falcon has reduced the rear spring rate for both sedans and station wagons by 10%. A smaller front stabilizer bar is used. Threaded, pre-lubricated metal bushings are specified in the front suspension upper arms.

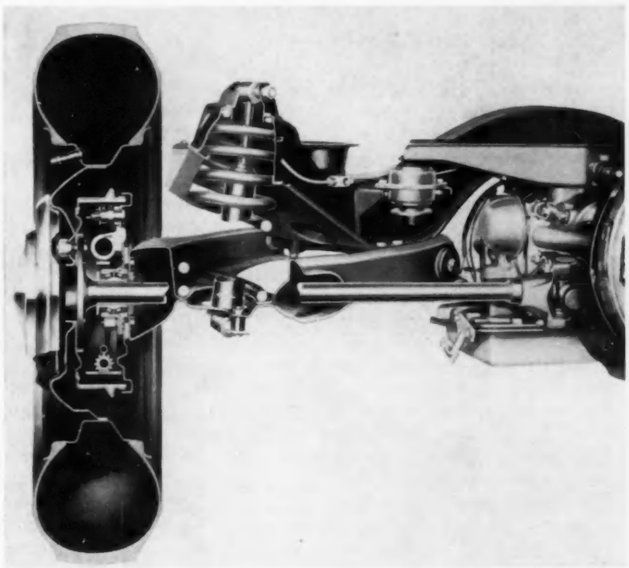




FRONT AND REAR WHEELS on the 1961 Mercury are free to move back (slightly) as well as up and down, providing cushioning against small bumps in the road such as tar strips and other irregularities in the pavement. A — front-suspension arrangement. B — rear-suspension arrangement.



FORD is pre-lubricating a number of chassis points at the factory with a special grease having a molybdenum disulfide base. Shown here is upper arm ball joint.



SWING-AXLE REAR INDEPENDENT SUSPENSION used on Pontiac Tempest is shown here.

Pontiac's front suspension lower arm is swept back farther for better antidive control. A new 4-link rear suspension offers greater stability, better ride, and improved resistance to shake. Sound absorption is also reported to be improved. In the rear suspension, heat-treated coil springs are mounted over the axle and have a rubber shim between the spring and the frame. Springs are attached over the axle to provide a softer ride with reduced shake.

New lower control arms have rubber bushings, and are angled inward toward the center of the car. Combined with new upper links this design is reported to provide improved handling.

Each upper control arm has rubber bushings at points of attachment on the differential housing and on the frame cross-member.

Two separate upper control arms replace the A-frame-type single upper arm to give improved stability.

Pontiac's new Perimeter frame has no diagonal members, which permits lowering the floor and a substantial improvement in seat height and passenger comfort.

The Pontiac Tempest independent front suspension has an A-frame-type upper control arm and a cantilever-type lower control arm with a compression strut. Stamped steel control arms are specified. Wheel caster angle may be adjusted by varying the effective length of the strut. Tops of coil springs seat against rubber shims. Half ball joints have phenolic seats. Tapered roller front wheel bearings are used.

Swing-axle independent rear suspension has the rear cross-member rubber-mounted to the integral body at four points. The differential and final drive gear-case is mounted to the sprung mass of the car. Axle shafts are driven through a universal joint on each side of the differential. Control arms are of the boxed section A-frame-type.

A completely new frame will be used on Olds' larger lines of cars. Instead of the cruciform structure with diagonal bracing, Olds uses full box section members extending all around the car. In place of the usual X-members, Olds is using torque box reinforcements to brace the four corners of the central section. The new design is reported to give greatly increased resistance to twisting and provides greater structural rigidity. It also provides a strong, wide step for both front and rear doors of the car.

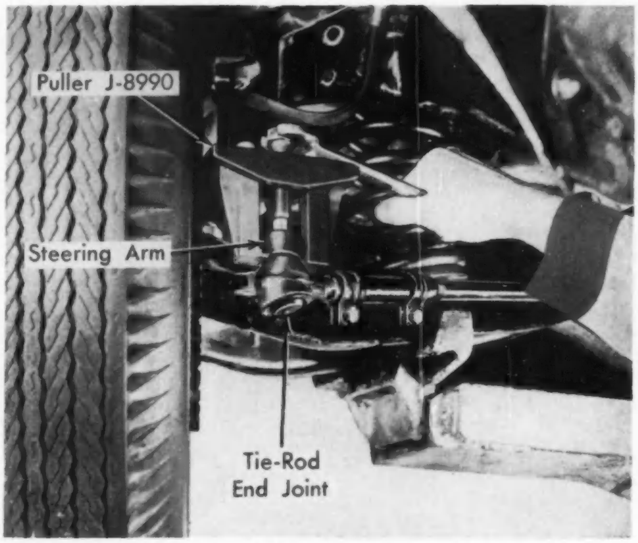
The Olds F-85 has a completely new ball-joint-type front suspension. The steering gear is mounted to a rubber-cushioned cross-member.

Coil suspension is used in the rear of the car. The twin-triangle unit has two rubber-mounted links on each side, connecting the axle and the differential to the side rail structure. The outer links transmit driving and braking forces and also control vertical stability. Inner links control lateral stability.

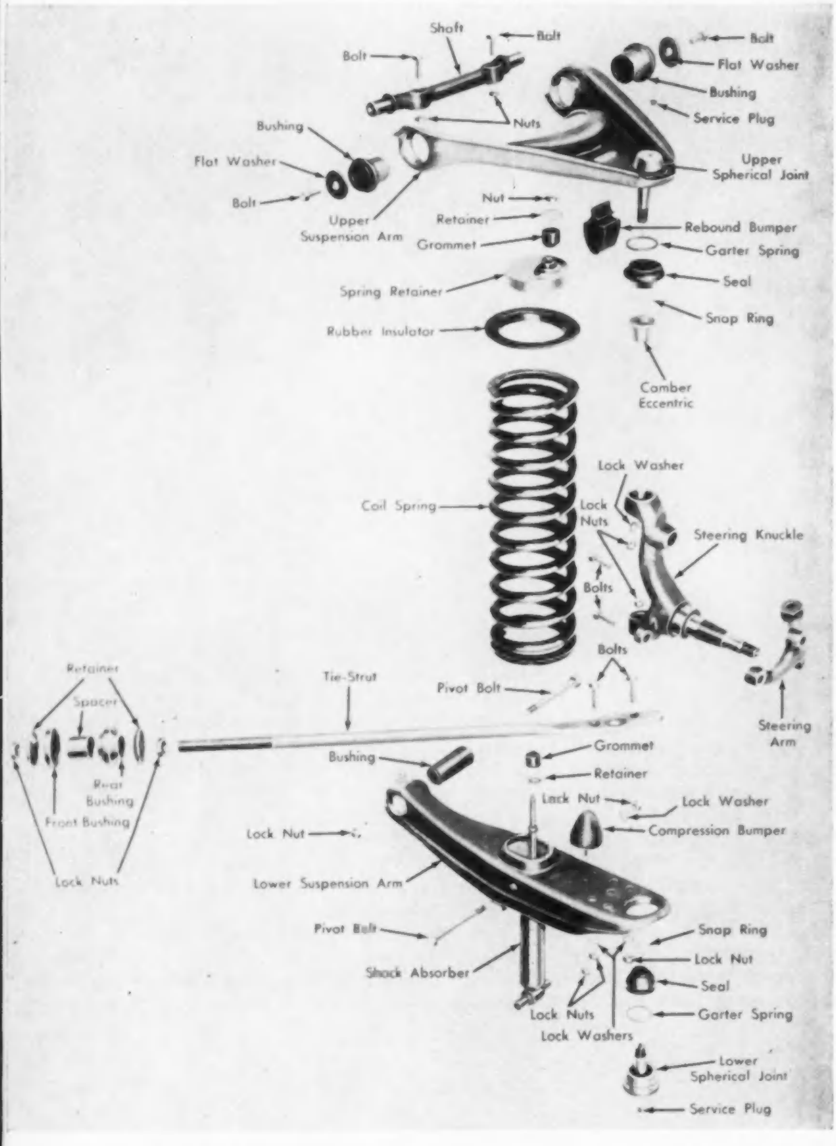
Greater rigidity and improved ground clearance of the differential housing are provided by the new suspension. Axle housing tubes are welded to the differential.

Modification of its ball-joint front suspension has made it possible for Olds full-size cars to reduce the number of lubrication points from 12 to 4. Periodic lubrication is now required only at the ball joints.

A 4-link coil suspension is used in the rear for 1961. Upper links



CADILLAC front-end tie-rod construction is shown here.



are angle mounted from the rear-axle housing to the frame; lower links are parallel mounted from the housing to the frame. The design is not changed substantially from the Olds air suspension, except that coil springs are substituted for air bags, thus taking advantage of much experimental work on suspensions undertaken by Olds in recent years. A softer ride with minimum dipping is claimed for the new suspension.

Elimination of the torque tube has permitted introduction of an entirely new Buick rear suspension. In this design, a pair of lower control links is connected to the frame at their front ends and to a bracket attached to the lower axle housing at the opposite ends. An adjustable third link prevents rotation of the axle housing. The third link assembly is a 2-piece construction, with each piece having a series of vernier-spaced holes and one slotted hole.

A reduction of 8 lb has resulted from redesign of the differential carrier. A track bar and cross-member assembly maintain a lateral relationship between the rear axle and the frame-body construction.

Front wheel hubs have been redesigned to permit the use for the first time by Buick of tapered roller front-wheel bearings. The redesigned front suspension has made possible a reduction in size and weight of the hub casting, with a potential improvement in life and bearing performance.

Buick's new cruciform frame has permitted weight reduction of approximately 30 lb on the LeSaber and the Invicta and 70 lb on the Electra. Greater torsional rigidity, improved stiffness, particularly at the corner positions, and improved floor design have resulted from the change.

A substantial part of the weight reduction has been accomplished by elimination of the side rails, permitting a reduction in the rear sill step-over. The new frame is of box-section, all welded construction.

Cadillac is now offering an en-

CADILLAC FRONT SUSPENSION is shown here in an exploded view.

tirely new front suspension. Suspension arms have rubber mounts, avoiding metal-to-metal contact. The single lower control arm has a tension strut rod that controls fore-and-aft movement as well as up-and-down motion. This greatly reduces the impact of small irregularities on the road such as tar strips. Air suspension has been dropped for 1961.

Cadillac this year is offering a lubrication-free chassis. Changing engine and transmission oil, and checking the oil level of axle, steering, and brake fluid are all of the attention necessary.

Oriflow-type shock absorbers on Chrysler Corp. cars have been redesigned for quieter operation. The base valve seat has been made narrower, with shallower grooves. This reduces the hydraulic force needed to open the valve, and it opens smoothly and quietly.

Six-cylinder Plymouths and Dodges now have five rear-spring leaves instead of four to give longer life without altering ride characteristics or load-carrying capacity of the car.

Torsion-Aire suspension on the Lancer assures an unusually flat, smooth ride, and the favorable front-engine weight distribution provides safe, predictable, cornering characteristics and freedom from wander on crowned roads and in gusty crosswinds.

Reapportioned X-members of Cadillac have made possible a lower floor. Weight and strength are retained. Lowering of the frame is a factor contributing to lowering of the front floor.

New brake designs . . .

. . . reflect the large amount of research and development work on the test track and on the expressway. Present trend toward larger drum swept areas may not hold up. More fin cooling adopted. Greater safety designed into parking brakes.

CADILLAC front brakes have been moved outward into the airstream. Fins have also been added to provide additional cooling. There has been no sacrifice in wheel offset or kingpin inclination. Coupled with new drum flanges, these improvements give a reported 59% increase in front brake cooling capacity. Stopping distance has been improved, with an increase in the braking effort on front wheels.

Brake drums for the 1961 Buick 4000 series are gray iron. The brake design features maximum drum-swept area with a car weight to swept area ratio of 12.05 psi. Total swept area is 224 sq in. The new parking brake mechanism has a pull-type operating handle. Release is accomplished by rotating the handle.

Drum swept area of the Buick 4400-4600-4700 series has been increased from 303 sq in. to 321 sq in. Primary linings have the center groove used previously; the secondary shoe does not have a center groove. This allows full width contact of the secondary shoe.

To assure return of the brake shoe to the correct position, Lincoln Continental has hard chromium-plated eight spots on the backing plate ledge. Drum swept area is actually smaller than a year ago but recent design changes, some resulting from studies of lining materials and their compatibility with drums, have made it possible for Lincoln to claim an increase of as much as 100% in brake life in the 1961 model. Another step taken this year has been tighter sealing to prevent dust and dirt accumulation inside the drum.

Flared cast-iron drums are used on Lincoln sedan models. Flared aluminum drums with cast-iron liners will be used on front only in convertibles. An improved brake booster has reduced the pedal effort required to make a stop by 20%.

Greater contact between the brake lining and the drum is provided in the new Ford brakes. Pedal geometry has been revised to increase the mechanical advantage and, therefore, reduce pedal effort. Linings are thicker and have more return-to-off spring action. A self-adjusting mechanism adjusts the shoes automatically. The system is actuated by application of the brakes during reverse braking.

Olds has a new anchor pin construction which insures constant correct relationship between the anchor pin and the brake shoes.

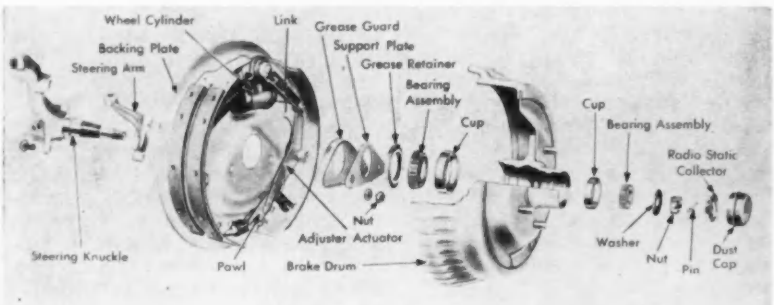
Chrysler has reduced parking brake effort by the adoption of a longer pedal arm, which increases the mechanical advantage of the system. A new release lever, adopted during 1960, must be pulled outward before it is pushed down to release the parking brake. The extra motion makes it almost impossible to release the brake inadvertently by striking the release lever. A similar system is used on Plymouth.

Comet brakes are lighter in weight and swept area has been increased.

Full-circle wheel openings and ventilated wheel covers (optional) promote Lancer brake cooling.

Rambler American has adopted suspended brake and clutch pedals for 1961.

Studebaker-Packard is specifying bonded brake linings. Effective lining areas have been increased 22% on 6-cyl models, 19½% on V-8's.



CADILLAC FRONT BRAKES have been moved out into the airstream without sacrificing wheel offset or kingpin location.

Exhaust systems . . .

. . . should give longer life. Dual mufflers are disappearing rapidly. Ceramic muffler, designed to serve for the life of the car, is introduced by American Motors.

AMERICAN Motors is the only U. S. car manufacturer offering a ceramic-coated muffler and tailpipe.

Using a process for coating steel with ceramic material developed by Bettinger Corp., the Walker Mfg. Co. is producing ceramic-coated mufflers and tailpipes for AM on an exclusive basis.

The coating process involves dipping the muffler assembly and tailpipe in a slurry of borosilicates, clay, borax, titanium oxide, and other refractory agents. After fire hardening in a continuous furnace at 1500 F, the ceramic coating is approximately 0.003–0.006 in. thick. To permit dipping, the muffler had to be completely redesigned.

After coating with ceramics, two protective layers are provided for the muffler. Asbestos insulation is applied and a 25 gage galvanized steel jacket protects against stone and other objects that might damage the muffler unit.

Lincoln Continental will use all flanged and bolted joints on the muffler. There are no slip joints. This step has been taken to promote longer muffler life. The Lincoln exhaust system is fully aluminized.

Cadillac has a new, single-type exhaust system. The unit has been designed particularly for long life.

Ford is offering an aluminized muffler and tailpipe. A double-wrapped muffler is specified, plus a laminated exhaust pipe. The cylindrical, 3-chambered inner shell is aluminized on both sides; the outer shell is galvanized on both sides.

Electrical equipment . . .

. . . must be made more reliable on passenger cars and a major effort is being made to pre-test equipment and simplify servicing. Wiring and switches are designed to be more foolproof both from the standpoint of installation and operation. Miscellaneous accessories, both electrical and hydraulic, are being redesigned, with addition of more power.

A SINGLE word, "reliability," describes the most important trend developing today in the electrical systems of U. S. motor cars. Pre-testing of electrical equipment is increasing. Serviceability of electrical equipment is also improving.

A TV screen is now used to identify defects in electrical harness that is pre-tested before installing in a Lincoln Continental. The single circuit under test is readily identified. Test loads are several times greater than normal operating loads.

The Lincoln Continental 80-amp battery is probably the largest in the passenger-car industry.

Additional nylon coating is used by Lincoln on all instrument panel wiring. All ignition wires are coated with Hylalon to avoid power loss.

The generator has a lower cut-in point to provide output at lower engine speeds.

A new starter uses positive engagement, eliminating false starts.

The voltage regulator includes a double contact voltage limiter, a molded cover gasket, and nylon washers.

Chevrolet has a removable console to which all dials, telltale lights, instruments, and controls are mounted. The single assembly or bench-type wiring harness contains all wires running between the instrument console and a dash-mounted junction block. This precludes the chance of loose wires, insulation chafing, and possible short circuit.

Ford (and others) are offering an electrical alternator as optional in place of the usual generator system.

Increasing production capacity at Chrysler Corp.'s electrical equipment manufacturing facilities is reflected in wider use of Chrysler-built electrical components. The alternator, introduced on the Valiant in 1960, appears on all Chrysler Corp. cars for 1961. The solenoid-shift starter, formerly used on DeSoto, Chrysler, and Imperial, is now used on all V-8's. The Chrysler-made distributor features a die-cast aluminum housing and nylon-content breaker points.

Several advantages are claimed for the new hydraulic windshield wipers installed on the Lincoln Continental:

1. They provide uniform wiping under all driving conditions.

2. They permit infinitely variable speed.

3. They offer unique ability to wipe a nearly dry windshield (with an 18-in. blade).

A separate electric pump is used for the windshield washer. Pressure of the water stream has been increased substantially. Aiming is accurate, even at very high speeds.

There is no slowdown during acceleration. The hydro motor derives its power from a return line of the power steering mechanism. A coordinated windshield washer cycles eight times at medium speed. Amount of water is controlled by a pushbutton.

To provide a better spray pattern, Rambler's windshield wiper nozzles have four holes each. The overlapping type is used on the American. The powerful piston-type booster pump provides 15 to 100 cpm.

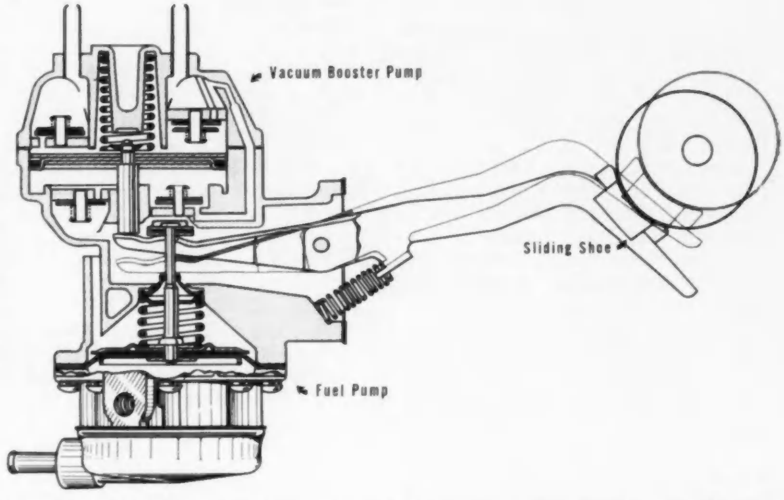
The rocker arm of AM's combination vacuum booster and fuel pump is activated by an eccentric on the engine camshaft. The piston booster pump operates in series parallel with the wiper motor and manifold vacuum source. When the vacuum falls below 14 in. (Hg), the piston booster supplies auxiliary power to the wiper motor.

The Carter piston booster is double-acting. Valves are spring-loaded rubber wafers. Design simplicity is indicated in the sectional drawing.

A new electrically driven windshield washer is available for Chrysler and Imperial. The new washer gives the driver complete control of the wash-wipe cycle. Power is supplied by a d-c motor less than 1½ in. long. It drives a positive-displacement pump to send four 13-psi jets of fluid against the windshield.

New tandem action, overlap electric wipers are available for the Pontiac Catalina and Ventura series. Wiper blades are 15 in.

For the Pontiac Star Chief and Bonneville, and optional on the Catalina and Ventura, overlap-type, 60–80 cpm electric wipers 18 in. long are offered.



VACUUM BOOSTER PUMP supplies additional power to the wiper motor used by American Motors.

Air conditioning and heating . . .

. . . Air conditioning trend is to faster cooldown, increased fresh air supply, and improved control. New units are being designed particularly for smaller cars. Chevrolet Corvair gets a perimeter-type heater using engine heat.

CORVAIR for 1961 will use heat rejected from the engine and distributed through strategically located outlets to warm the car. The gasoline heater now used is being continued.

In the new free perimeter system heater, hot air from plenum chambers surrounding the right- and left-hand engine banks is transferred through circular ducts to a rectangular chamber located above the blower. Warm and cold air are blended in this chamber.

American Motors has a completely redesigned heating and air conditioning system. A single damper control regulates the heater and defroster air distribution. A new centrifugal blower has replaced the bladed fan.

The heater and air conditioning units for the 108- and 117-in. Ramblers now have a single-control damper, eliminating as many as four dampers, previously used.

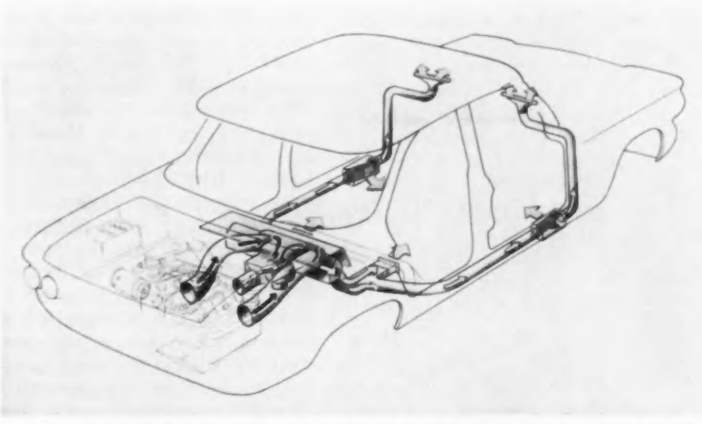
The heater provides better air distribution in the front passenger compartment, as well as in the rear. The front seat cushions are revised at the sides and center to provide freer passage of air to the rear seat area. The rear distribution is accomplished by a center door in the heater housing.

A single housing is used to house both fan and heater core.

The material used is fiber-reinforced polyester resin. The single molded housing replaces both molded housing and steel stampings. After molding, the housing is placed in a metal dryer to assure accuracy in keeping the mounting surface flat and straight. A soft, closed-cell sponge gasket is used for sealing.

The one-piece molded housing gives low tool and piece costs, when compared to previous steel stampings. The total unit is easier to seal and free from rattles.

The new air conditioning system provides for a separate blower, where previously the heater and air conditioning were operated by the same blower. For faster and more efficient cooling, the system,



HEATING DIAGRAM for Chevrolet's perimeter warm air heater. Chevrolet dealers will continue to offer the Chevrolet gasoline heater.

with its own 3-speed blower and air passages that are completely separate from those of the heater system, increases the cold air flow 10–15%. Adjustable cold air outlets are centrally located at the top of the dash panel.

Separate fresh air openings are provided on the 1961 model, whereas fresh air was taken in through the heater core of the 1960 model.

Improvements by Lincoln include:

1. Faster cooldown.
2. Increased quantity of cool air from registers.
3. Better rear compartment cooling.
4. Simplified assembly and servicing.
5. Wider range of temperature control.

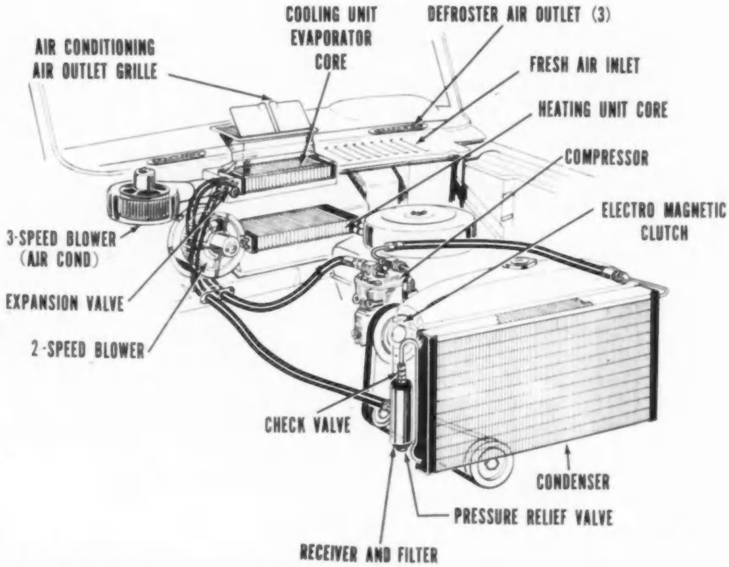
The large air conditioning evaporator is mounted in the firewall, directly behind a retracting air conditioning console. The twin turbine blower is located in the engine compartment.

To achieve optimum cooling without sacrificing engine performance, an idle speed regulator is used. This permits smoother idle and less creep at stoplights. An electric solenoid automatically advances engine idle when the air conditioning system is being used.

New air conditioning units for the Olds F-85 have been designed particularly to meet the requirements of a smaller car. Evaporator and blower units are mounted inside the car. Air distribution is adjustable at both ends of the instrument panel. Improved supply of fresh air is available. The new unit has pushbutton controls.

A fresh-air heating and ventilating system similar to that on the Valiant is an option on the Lancer. Pushbutton heater controls are arranged in a horizontal row to the right of the instrument cluster. A temperature control knob slides horizontally beneath them. Knobs at either end of the instrument panel open the fresh-air doors for summer ventilation.

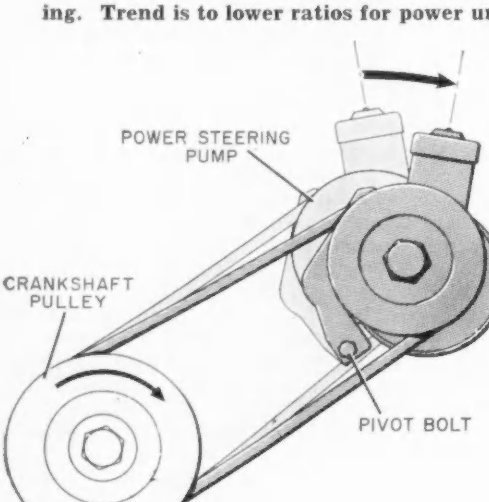
The Chevrolet deluxe heater offers quicker response and more accurate temperature control, as well as improved windshield defrosting and better direction of airstream.



HEATING AND COOLING SYSTEM offered by American Motors for 1961 has been completely redesigned. A single damper control regulates distribution of heater and defroster air.

Steering . . .

. . . Greater accuracy and freedom from vibration are primary objectives in steering gear design. Use of flexible couplings on manual units is increasing. Lincoln Continental has a cooling unit on its power steering. Trend is to lower ratios for power units.



DODGE POWER STEERING PUMP features a self-tightening drive. The light illustration shows the "no load" condition. When steering effort is applied, the belt tightens as shown, preventing slipping.

A SELF-TIGHTENING power steering pump drive is available on most Chrysler cars with V-8 engines. The pump pivots freely on its mounting bracket and is located so that, when the engine is not running, only the weight of the pump pulls against the belt. When the engine is running, the load imposed on the pump by the power steering system causes one side of the belt to be tighter than the other. The geometry of the pump mounting is such that this difference in forces tends to pull the pump away from the engine, tightening the belt with a force proportional to the load on the pump. A high initial belt tension is unnecessary, bearing loads are decreased and belt life is lengthened. Belt stretch is automatically compensated for, eliminating the need for adjustment.

Addition of a cooling unit to the power steering unit (Lincoln Continental) maintains uniform, constant temperature, assuring constant steering conditions.

Introduction by Cadillac of a smaller steering wheel necessitated limited changes in the gear and pump. Ratio is reduced from 18.9/1 to 18.2/1, lowest in the industry. Steering angle has been increased from 36 to 38.5 deg. Turning radius is reduced 3 ft.

The Lancer manual steering gear is a low-friction type employing ball and needle bearings on every part that turns. Gear ratio is 20/1. With the optional power steering, the ratio is lowered to 15.7/1.

A new flexible coupling in the Ford steering shaft has resulted in substantial reduction in vibration and harshness. The manual steering ratio has been increased from 20.1 to 22.1. Needle bearings replace the bronze bearings used previously.

Manual steering installations on Pontiac now have a flexible coupling at the junction between the gear assembly and mast jacket and shaft assembly. In the Pontiac, a forged linkage has replaced the previous tubular design. A ball joint has been added at the lower end of the idler arm.

Larks are equipped with a new design of recirculating ball-type steering gear. In addition, the caster angle has been changed from 2½ deg negative to zero degrees, and the knuckle upper bushing is a new type, precision ground to reduce friction.

These changes have resulted in 30% reduced steering effort on 6-cyl models, and 10% on V-8's. Steering response, directional stability, and recovery after turns have all been improved. Power steering is now available on all Lark models.

Body engineering . . .

. . . Chevrolet's Greenbrier is the first van-type passenger car to go into volume production. Thinner doors reduce car width but not passenger space. Superwide wraparound windshields and the "dog leg" are bowing out. Gains for 1961 are easier entry and exit, better seating, more legroom and headroom, and a flatter floor. Today's trend to unitized bodies is mixed.

WITH an entirely new body, Cadillac engineers have concentrated on providing more convenient entrance, increased head room, greater chair height and leg room, and improved seating position. Distance from depressed front seat *A* point to the floor has been increased almost 50% on some models. Headroom is increased as much as 2 in. on several models.

Rear tunnel reduction is due mainly to frame changes and a redesigned exhaust system.

This year emphasis has been placed on improved comfort for the driver and the passenger. With elimination of the wraparound windshield, the "dog leg" has been eliminated.

In the 1961 Cadillac, the frame is completely isolated from the body structure with new and relocated rubber mounts. New mounts have been added over the rear axle.

Chevrolet's van-type sports vehicle — the Greenbrier — has independent suspension and frame-integral body engine-in-the-rear with forward control. It is the first of its kind to be built in large volume in this country for passenger use.

The frame body is comprised of five substructures: underbody, front end structure, right- and left-hand side panels, and the roof panel. There is a "dropped center" flat floor between the kick-ups. Minimum ground clearance is 6.6 in. at design load. Capacity is 1600 lb.

Underbody is sprayed by Chevrolet with high Zn content chromate primer to combat corrosion. Enclosed areas are sealed with a compound consisting of Al particles suspended in a wax base. Before welding, underbody flanges are treated with a rust-inhibiting compound.

Lincoln Continental has a novel "dual density" seat construction, providing some of the characteristics of bucket-type seats but without requiring separate seats. High-density foam rubber 4½ in. high is used to a depth of about one-third of the seat. Lower-density foam rubber is used for the remaining portion of the seat. Application of the body weight compresses the less dense rubber to a greater degree, providing, in effect, a contour-fitting seat that resists the tendency for the passenger to slide on the seat. Foam rubber is also used in the back of the seat.

The center door pillar is welded directly to the underbody side sill and rocker panel, providing, with a rear-hinged rear door, a strong bulk-head base. Advantages claimed for the design include minimum door sag, more solid closing doors and a better fit and seal.

Side sills or rails are double box members. The front floor is a single stamping. Transverse cross-members at front and rear edges of the front seat provide support for front passengers. Front torque boxes are located under the dash and the toe pan between the side sill and front suspension assembly.

Rear floor, extending from the rear torque box to the rear of the body, is supported by two side rails, tied together by a box cross-member.

The competitive position of the 1961 American is made clearer by an analysis of body dimensional changes. While the wheelbase remains at 100 in., overall length is 5.2 in. shorter and width is 3.0 in. narrower. Sedan is 1.1 in. lower and the station wagon is 1.7 in. lower.

Usable trunk space has been increased 50% (except on convertible) by redesign of sheet metal and vertical mounting of the spare tire behind the rear seat instead of flat on the trunk floor.

Hood width of the Ford has been reduced 11 in. Increased fender width permits the use of a 1-piece upper apron and radiator support.

Major changes have been made in the body side structure to provide increased bending rigidity. Strengthening these areas assures more effective door and window

sealing in these cars.

Ford is specifying tempered glass for all side windows in 1961.

Roof of the new Chevrolet standard body is tied in more effectively to the lower structure. Underbody is reinforced; dash panel is strengthened.

Olds compact F-85 weighs 1500 lb less than conventional Olds models. About one-third of the weight savings is attributable to the aluminum engine; other savings in weight result from a smaller body designed specifically to save weight while providing optimum rigidity and strength.

Olds F-85 features frame-integral construction. Tunnel heights are minimized and seat heights have been raised. At the same time, headroom has been increased and entry and exit are improved.

Horizontal stiffeners have been welded to the outer door panels on the Mercury to provide added door strength. Floor underbody is reinforced. Body mounts (16 on sedans and station wagons and 18 on hardtops) are designed to tune out road vibration.

Crash pads will be standard on all Studebaker-Packard cars. An oval steering wheel has been adopted to improve driver visibility.

Covering all floor pans of Lincoln Continental is an asphalt-impregnated felt sound deadener weighing ¾ psf. Insulating materials cover all body access holes and openings. Grommets in the dash panel area have sound-sealing features.

Bands of undercoating are applied longitudinally to the outboard areas of the underbody. Dash panel is insulated with 2½ lb density fiberglass, 1 in. thick. A blanket of fiberglass 2 in. thick is spread over the area beneath the instrument panel.

Door outside panels have felt insulator oversprayed with sound deadener. Pockets and hollow areas (such as those between the rear wheelhouse and the quarter panel) are filled with cellulose wadding-type, sound absorbing material. In air conditioned cars, ½-in. fiberglass, faced with aluminum foil, is placed at critical floor pan areas.

Underhood sound deadener is a fiberglass compound with a black outer protective skin.

Among the areas on the Mercury to get additional or sound insulation are: hood, dash panel, cowl sides, steering column, floor panel, under rear seat, roof panel, instrument panel, and rear wheelhouse.

A new hood-silencing treatment by Chrysler consists of bonding the inner reinforcing panel to the outer panel with many drops of oven-curing expandable sealer, each placed in a critical location. The sealer acts as a bond between the panels and provides a highly effective damping medium.

Cars equipped with factory undercoating have a new underhood silencing pad made up of a layer of high-density fiberglass plus die-cut blocks of low-density fiber glass, which fit in the interstices between the inner and outer panels. Mechanical fasteners provide positive retention.

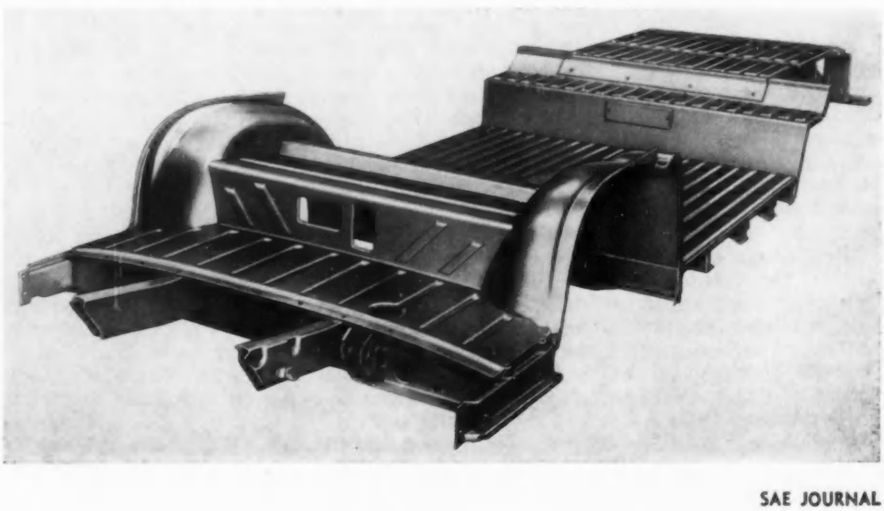
Lincoln Continental (and others producing unitized bodies) are taking many steps to protect body structural members from the effects of both interior and exterior corrosion. Dipping to the belt line is used to insure complete coverage of inside areas. In the case of Lincoln Continental, galvanized steel is specified for many interior surfaces. Galvanizing and dipping is followed by normal painting procedures.

Front end fender reinforcements for Ford models have been completely redesigned to provide better drainage and baffling. A splash apron, added to the forward part of the fender, prevents corrosion in the headlamp eyebrow.

Chromium thickness on Ford plated parts is said to be more uniform and anodized coating of aluminum parts is 2½ times thicker than 1960 specifications. All Ford rocker panels will be made of differentially coated steel galvanized on the inside only. New seals prevent corrosion around headlights.

The 7-stage Chrysler Unibody corrosion protection process has been improved by the addition of two steps: (1) the application with a lance-type spray gun of primer to the inner surfaces of the body sills, and (2) a coating of wax-like compound on the inner sill surfaces after the primer coats have been oven-dried. These steps insure total protection of the vital sill structure.

Rocker panels for Mercury are galvanized for improved rust prevention. Weld sealers and primers are used between welded parts to provide a protective coating in areas where moisture evaporates slowly. A 5-step cleaning and rustproofing precedes application of primer and painting. Abrasion-resisting mastic protects fenders and areas likely to be chipped by stones.



FLOOR OF CHEVROLET GREENBRIER— America's first van-type station wagon.

Turbines Safer and More Reliable

... than piston engines, say airlines. Performance exceeds expectations

Based on report by secretary

T. J. Harris

General Electric Co.

TURBINE performance in airline service has been excellent and has increased the safety and reliability of operation. Turbines are by no means perfect but even with their deficiencies, which are in process of being corrected, they have exceeded the expectations of operators.

When a comparison is made with the piston engine, the credits very definitely outweigh the debits, and the margin in favor of the turbine is increasing.

Here are the credits and debits for the turbine as seen by airline operators:

Credits

Rate of increase in time between overhauls — The rate has been spectacular; 2 to 2.5 times as fast as the piston engine.

Aggregate service life between overhauls — This is expected to be 1/4 to 1/2 again as great as that of the best piston engine. A TBO of 1000 hr has been reached by many and it will become greater, especially for cold sections.

In-flight shutdown rate — Significant improvement over the piston engine.

Engine failures — When the turbine is right, the rate is about twice as good as that of the piston engine. One airline reports no failures in its most recent three months of operation and about double the number of engine hours per basic premature removal in contrast with its piston engines.

In service defect rate — Flight squawks as distinct from engine failures are reported to be less. One operator puts the figure at 5–10% of that normal for piston engines.

Delay rate due to prime mover — About 50% that of the piston engine. The improvement in basic engine reliability has shown up deficiencies in components hung on it or on the power package.

Rate of engine defects — Fewer and usually confined to bearings or turbines.

Engine trouble-shooting — There are fewer things to go wrong and what does misbehave is more obvious.

Secondary effects of engine failures — Safer in this respect.

Engine operating procedures — Easier, particularly with the pure jet.

Engine inter-overhaul maintenance — About 50% that of the piston engine.

Oil use — Changes nil; consumption negligible.

Accessibility — Much improved. Fewer parts likely to require change in service.

Debits

Fuel quality — Standards are higher than for a piston engine. Dirt and water are intolerable.

Foreign body entry — Susceptibility is higher and more time and money are required to keep runup areas clean. However, the problem is not as serious as anticipated.

Engine starting — More critical, expensive, and costly to maintain. Some operators report performance unsatisfactory.

Engine rectification after failure — Likely to be more expensive because of component cost.

Engine overhaul — Material costs appreciably greater and more floor space required.

Serving on the panel which supplied the facts for this article were the secretary and W. D. Sherwood, Trans. World Airlines (chairman); J. E. Conner, Pan American World Airways; W. R. Neely, American Airlines; Ray Peck, Pratt & Whitney Aircraft; M. H. Pomeroy, United Air Lines; John Romeril, British Overseas Airways; R. B. Smith, General Electric Co.; and Fred Steuber, Allison.

Plasma Engine holds great promise for space travel

Based on paper by

S. W. Kash

Lockheed Aircraft Corp.

PLASMA and plasma phenomena seem destined to play an important role in communications, space travel, and in power production in areas not yet conceived. Propellant material in plasma propulsion can be accelerated to tremendous velocities by the use of electromagnetic forces.

It is possible that the first application of electrical propulsion in space will involve the use of a small plasma engine to help to stabilize a communication satellite or change its orientation. After that would come larger units for orbital transfer and, finally, engines for planetary travel.

What plasma is

Plasma is a gas containing an appreciable number of ions and electrons, with equal amounts of positive and negative charge so that the gas is neutral from a macroscopic point of view. It can be considered a fourth phase of matter, the phase beyond the gaseous one.

The attraction of electrical propulsion, such as plasma propulsion, lies in the long-range possibility of its providing a large ratio of payload to initial vehicle weight, resulting from the use of higher velocity propellants. The greater the exhaust velocity of the propellant, the larger the payload fraction for any given mission. Fig. 1 shows that the payload fraction varies with propellant velocity for a uniform thrust which produces a vehicle velocity change of 30 km/sec. This change would carry out most interplanetary missions.

The feasibility of electrical propulsion rests on two relatively recent technical developments. The first is the nuclear reactor, which provides a potentially unlimited source of energy. The second is the ability to put increasingly greater weights into satellite orbit. However, the great cost of lifting material into satellite orbit makes it highly advantageous to develop space ships with as large a payload fraction as possible.

Higher propellant velocity entails lower engine thrust because of powerplant limitations. This rerults from the fact that, for a fixed thrust, the power is proportional to the propellant velocity. By starting in a low-drag satellite orbit we can use a low-thrust, long acceleration-time powerplant very advantageously.

Engines for space

There are several types of engines possible to use for space travel. These include:

- Chemical propulsion.
- Nuclear-chemical propulsion.
- Propulsion by electrical arc heating (plasma jet).
- Ion propulsion.
- Plasma propulsion.

In chemical propulsion systems both energy and propellant are contained in a fuel-oxidizer mixture which is burned in a combustion chamber to produce high-temperature gases. The gases are allowed to expand through a nozzle to convert part of their internal heat energy into kinetic energy of the exhaust. Such units have been operated successfully, but there is a limit to the propellant velocity to be had with chemical fuels. Even with fuel mixtures which combine the most energetic chemical bonds with the lightest weight atoms, propellant exhaust velocities greater than 4 km/sec are unlikely.

Higher velocities can be achieved by combining a nuclear heat source with a light chemical propellant. The propellant is heated by passing through a reactor and accelerated by expansion through a nozzle. Velocity is limited by the temperature to which the propellant can be heated, that is, primarily by the temperature of the reactor material. A velocity of about 6 km/sec could be obtained with hydrogen

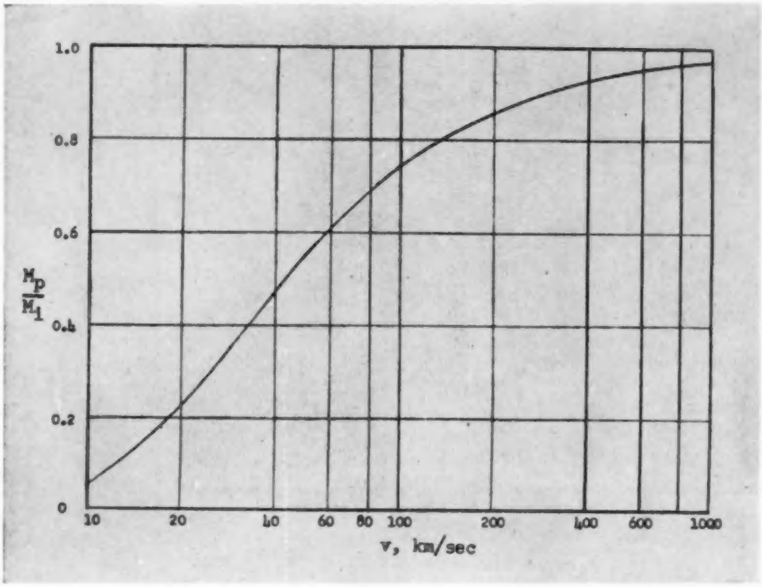


Fig. 1—This shows how payload fraction varies with propellant velocity for a uniform thrust producing a vehicle velocity change of 30 km/sec. Such a velocity would be adequate for interplanetary missions.

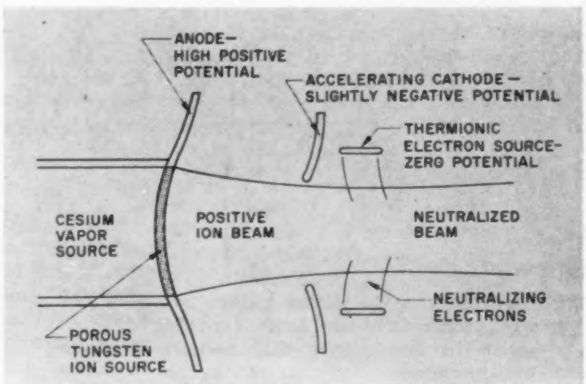


Fig. 2—Electrostatic ion accelerator affords the simplest means for accelerating material by electromagnetic forces. Disadvantage is the large exhaust area needed for appreciable thrust.

heated to 2000 C. If a way could be devised to deliver the kinetic energy of the nuclear fission fragments directly to the propellant, a velocity possibly 50% greater could be achieved.

Getting still higher velocities

Heating the gas electrically as with a plasma jet would give higher temperatures and velocities. Here the gaseous propellant is heated to high temperature by passing it through a high current, electric arc. The gas is then accelerated by expanding it through a nozzle. Properly speaking, the plasma jet is not to be classed with electrical propulsion devices. The propellant velocity is limited by material temperatures, but ultimately may achieve 15 km/sec.

Ion propulsion (Fig. 2) provides the simplest means for accelerating material by electromagnetic forces. Only ions of one sign can be accelerated by an electric field, hence ions have to be sorted out prior to their acceleration. Moreover, to maintain overall charge neutrality on the vehicle, ions of both signs have to be eliminated. Again, in order to maintain a neutral space environment in the vicinity of the ion engine, the positive and negative charges should leave the vehicle with about the same velocity. Because of the large magnitude of electrostatic forces, the ion currents that can be obtained are very small. Thus a very large exhaust area is required to get an appreciable thrust. We can expect the thrust per unit area from an ion engine to be no greater than about 0.1 lb/ft^2.

Merits of plasma propulsion

In plasma propulsion units a neutral plasma is accelerated with the aid of electric and magnetic fields. The magnetic fields can be provided by currents in the plasma, or independently. The propellant energy is supplied by the electric fields. However, the magnetic fields are required to orient the gas and give it a net momentum. A plasma device does not require separation of the positive and negative charges, therefore, it can handle larger amounts of propellant and can provide a larger thrust per unit area.

There are two types of plasma propulsion devices. One is the steady-state plasma accelerator; the

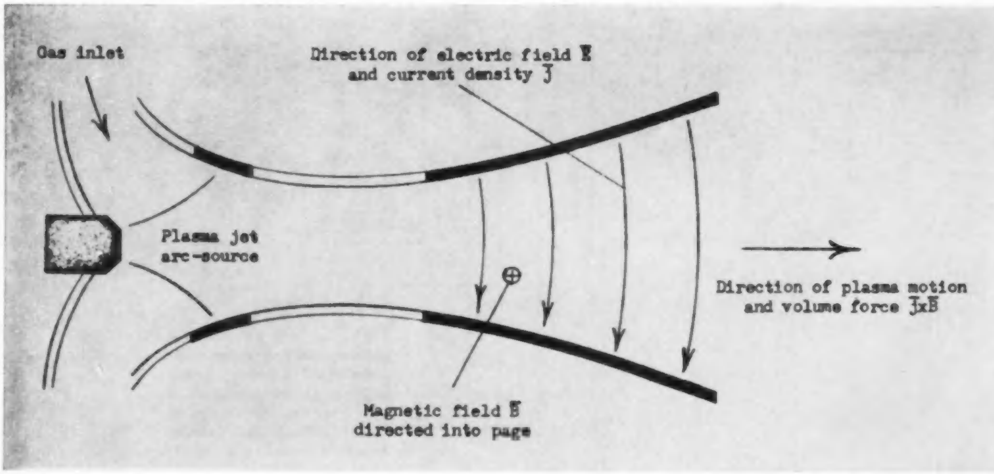


Fig. 3 — Steady-state plasma accelerator should produce per-unit-area thrusts up to 100 lb/ft², or three orders of magnitude greater than that of an ion engine.

other is the pulsed plasma accelerator. Steady-state devices may be suitable for the acceleration of plasma to intermediate velocities, up to perhaps 50 km/sec. The pulsed devices can be used to accelerate plasmas in the 10–500 km/sec velocity range, but are better suited for velocities greater than those of the steady-state devices. In these devices the basic principles are the same, but the technical problems differ greatly. The differences are analogous to those between d-c and a-c electrical devices.

Steady-state plasma accelerator

The d-c plasma accelerator is often called a crossed electric and magnetic field accelerator, and it is similar to that of the electromagnetic pump now used to pump metal liquids. In a simple version (Fig. 3), a plasma arc jet is used to produce a high-temperature gas to which has been added about 1% of an alkali vapor, such as cesium or potassium, to increase its electrical conductivity. The plasma gas then passes between a pair of electrical plates to produce a current transverse to the flow, and a set of coils which provide a magnetic field at right angles to both the current between the plates and the direction of flow. The resultant interaction between the current and the magnetic field provides the force for accelerating the gas.

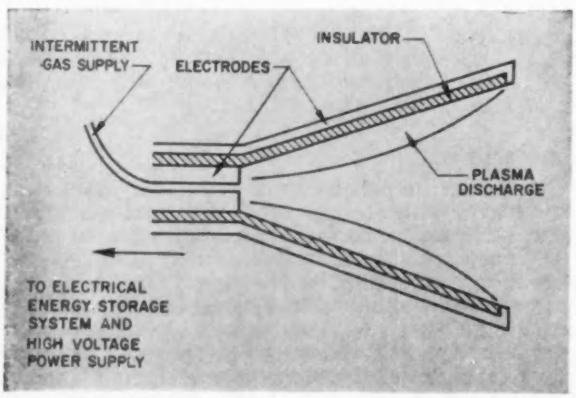


Fig. 4 — Pulsed plasma accelerator of the pinch type. Radial component of the current in the plasma contributes directly to the thrust; the axial component contributes indirectly through plasma compression and heating.

Pulsed plasma accelerator

The pulsed plasma accelerator is an intermittently operated device and can produce a per-unit-area thrust intermediate between the ion accelerator and the steady-state plasma accelerator. In this device, bursts of plasma are driven by rapidly varying magnetic fields produced by large currents in the plasma discharge. There can be a number of different electrode arrangements and in each of them a plasma, introduced into the discharge region or produced by the discharge, is accelerated by the interaction of the current in the plasma and the current in the fixed part of the discharge circuit. The current elements in the parts of the circuit nearest the plasma generally contribute the most to the acceleration.

In the collinear electrode plasma accelerator the principal force arises from the repulsion between the current element in the plasma and the antiparallel current element in the adjacent portion of the circuit. The acceleration in the coaxial electrode system is provided by the repulsive interaction between the disc-sheet plasma current and the current in the central electrode. In the pinch accelerator the accelerating force arises from the attractive self-interaction of the axially symmetric current sheet (Fig. 4).

Measurements and analysis indicate that pulsed plasma accelerators can be built which will convert electrical energy into plasma kinetic energy with an efficiency exceeding 50%.

To Order Paper No. 185B . . .
from which material for this article was drawn, see p. 6.

How to Design Gears to Resist

•Bending fatigue
•Compressive failure
•Scoring
•Splitting planet pinions

Based on paper by

Evan L. Jones
Chrysler Corp.

A GEAR DESIGN must provide sufficient strength to resist bending fatigue; compressive failure; scoring; and splitting of planet pinions under high load.

Bending stresses

Most important for durable automotive transmission gears is ability to resist bending fatigue. In selecting design parameters in developing the helical gear teeth, conflict arises between the requirements for durability and for quietness. A change in pitch, pressure angle, or helix angle, to help the noise situation, for example, usually tends to reduce durability . . . and vice versa. Items that tend to smooth the transfer of load from one tooth to the next tend to influence durability and quietness together. In this latter category are profile contact ratio, face width, and modifications of profile and helix to keep heavy contact off the tooth boundaries.

Criteria for selecting design parameters for transmission gears are as follows:

DIAMETRAL PITCH—Use as fine pitch as possible, consistent with manufacturing considerations. Select gear diameters to meet durability requirements. Normal diametral pitches used in current transmissions include:

12–20 for planetaries.
6–11 for passenger car manual shift.
5– 9 for truck manual shift.

Sliding gears have the coarsest pitches used in manual transmissions in order to meet the additional requirement of adequate tooth thickness for withstanding the crushing loads imposed by butting against unsynchronized mates.

PRESSURE ANGLE—Normal pressure angles in use today range from 16 to 25 deg in manually shifted transmissions, and 18 to 24 deg in planetaries. The lower pressure angles are favored for quietness.

HELIX ANGLE—Helix angles are usually made as high as thrust considerations will permit. Helix angles in use range from 15 to 23 deg in planetaries. In manually shifted transmissions, helix angles used for low-speed and reverse gears range from 19 to 31 deg. Other helix angles in these transmissions are selected to balance thrust on the countershaft, reaching 45 deg in some cases.

TOOTH DEPTH PROPORTIONS—Adjust addenda to balance bending fatigue life and to provide profile contact ratio more than 1.4 where possible. In multipinion planetaries, the sun gear often accumulates stress cycles faster than the planet pinions, in which case it needs more strength than the planets.

ROOT CLEARANCE—Provide clearance adequate to permit use of full-radius root fillets where possible. This practice will usually not penalize the strength factor much, but it will reduce stress concentration effect materially. The result is usually a substantial net gain in fatigue life.

Getting additional capacity

To get additional capacity from a given space, using existing gear cutters, shotpeening of the finished gears may add as much as 15–30% to their

How to

Design Gears . . . continued

capacity, if gear tooth strength, and not improper mounting conditions, is the limiting factor.

If the gear set is made up of simple planetary elements, a large boost in capacity can be made by using additional planet pinions to divide the torque among more tooth contacts. Although four or six pinions may not share the load equally, fatigue tests have shown conclusively that the extra pinions contribute a large increase to the capacity of the gear set.

Highly refined methods have been developed for calculating gear tooth bending stresses.

The accompanying table lists recommended maximum gear tooth bending stresses for new passenger-car transmission designs of various types.

ALLOWABLE BENDING STRESSES for hardened steel gears in passenger-car transmissions

Type of Transmission	Forward, psi	Reverse, psi
Manual Shift	90,000	120,000
Fluid Coupling	80,000	130,000
Torque Converter	130,000	150,000

The table is a composite of stress criteria used by various passenger-car transmission designers. Since some of these stresses are based on laboratory tests and some on vehicle tests, the level of vehicle life associated with each stress is somewhat uncertain. The table should be considered a guide, and no more.

Calculated stresses in some transmissions in current use exceed the design maxima listed in the table, reaching values as high as 180,000 psi on forward gears. Stresses this high probably result from increasing engine displacement without changing the transmission gears. Thorough testing in vehicles is done to establish the adequacy of such highly loaded gears.

Stresses in nonshotpeened gears in heavy-duty truck transmissions should be limited to 80,000 psi in forward speeds and 90,000 psi in reverse, for design purposes. Reason: high torques are sustained for longer periods in a loaded truck, resulting in more rapid accumulation of high-intensity stress cycles.

The allowable gear stresses shown in the table for fluid coupling transmissions are lower than for torque converter transmissions. The reason for this may be seen in Fig. 1, which permits comparison of the different output torque characteristics obtained from a transmission equipped with a fluid coupling, with another using a torque converter.

The maximum torque that can be applied to the gears with the torque converter is over twice the maximum possible with the fluid coupling. If the gears in the fluid coupling transmission were designed to be stressed as high as those in the torque converter transmission at stall, they would fail quickly because they would get far more maximum stress cycles.

The torque impulse imposed during the power upshift at 45 mph could affect gear life in the fluid coupling transmission if the shift were excessively sharp. This impulse is insignificant with a torque converter because of the much greater magnitude of the stall torque. The shift effect, plus the greater number of cycles which are accumulated in automatic transmissions due to the use of passing gear, contributes to the difference in allowable stresses shown between fluid coupling and manual transmissions.

Compressive failure of tooth surfaces

Prolonged operation of gears at high contact stress can produce compressive fatigue failure. Failure usually begins with individual pits forming in the vicinity of the pitch line. Under continued operation, pitting can progress into spalling, which is a more extensive form of surface fatigue.

As a general rule, the tendency toward compressive fatigue failures increases with coarsening pitch (larger teeth). The reason: bending strength increases faster than compressive strength as the teeth are made larger. Pitting, for example, is a relatively minor problem in the fine pitch gears used in passenger-car planetary automatic transmissions. But it occurs more frequently in the coarser pitch gears used in manual shift transmissions.

A formula for calculating pitch line compressive stress in external helical type transmission gears (adapted by Huffaker from a Hertz equation for contact stress between cylinders) is:

$$s_c = 0.59 \cos \psi \sqrt{\frac{2\,W_t E}{F \sin(2\phi_n)}\left(\frac{1}{d} + \frac{1}{D}\right)}$$

where:

s_c = Maximum compresive stress, psi
ψ = Helix angle at operating pitch diameter
W_t = Tangential tooth load at operating pitch diameter, lb
E = Young's modulus of elasticity, psi
F = Active face width (axial), in.
ϕ_n = Normal operating pressure angle
d = Operating pitch diameter of pinion, in.
D = Operating pitch diameter of gear, in.

This formula applies where contacting gears are made of materials with substantially the same moduli of elasticity. It can be adapted to internal gears by changing the plus sign to a minus sign.

Tests show that the surface fatigue life of hardened steel gears running under conditions of proper lubrication and cooling will be practically infinite if the calculated contact stress is 200,000 psi or less. Applying the principle of designing for finite life according to the anticipated usage of the various gears, contact stresses as high as 500,000 psi have been applied in low-speed gears of passenger-car manual shift transmissions. Second speed gears, which are used for larger numbers of stress cycles, are stressed as high as 350,000 psi.

Truck usage of the lower speed gears represents a larger fraction of total transmission life than does

5–9 for truck manual shift. ished gears may add as much as 15–30% to their

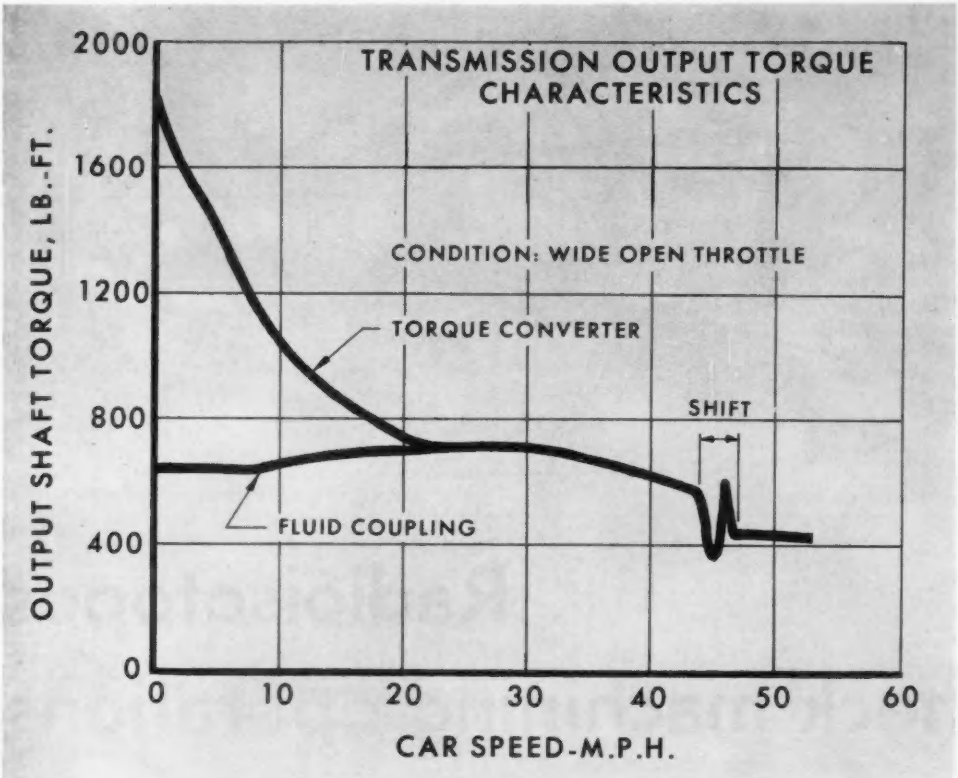


Fig. 1 — Comparison of torque outputs from a transmission equipped with a fluid coupling and from one with a torque converter.

passenger-car usage. This requires that the compressive stress level used for trucks must be lower than passenger cars. The best way to do this is to apply an S-N curve, in which stress is plotted against number of cycles to failure.

Gear tooth scoring

Scoring of gear teeth is not encountered in automatic or manually shifted transmissions used in passenger cars. The smaller transmissions are free from scoring because the gear tooth sliding velocities are low enough to avoid trouble. Fine pitch teeth and planetary gears give the automatics a comfortable margin of safety.

The larger manually shifted transmissions run with calculated values of *PVT* scoring factor approaching the borderline scoring criterion of 1.5 million (for mineral oil). Heavier duty manually shifted transmissions, with larger diameter gears and larger teeth, might have *PVT* values in excess of 1.5 million, with consequent danger of producing scoring failures. It is recommended that such gears be checked for scoring tendency by calculating the *PVT* scoring factors at the tips of pinions and gears.

If a potential scoring problem is found, it may be necessary to revise the outside diameters of the gears, modify tooth profiles for smoother transfer of load from tooth to tooth, or to use a lubricant with more antiweld protection.

Preventing planet pinion splits

Splitting of planet pinions under high load is related to the bending stress of the teeth; but it is not a tooth failure. The splitting is caused by insufficient stock between the bore of the pinion and the root circle.

The wall section under the teeth must carry tensile load equal to the tooth load, while its outer fibers are subjected on the bore side to high compressive stresses from the needle bearings — and on the tooth side to added tensile stresses imposed by tooth bending.

Because of the strong influence of the bending stress in the root, there is no hard and fast rule for how thick to make the stock under the teeth. Indications are that wall thickness under the teeth can be slightly less than the whole depth of the teeth when the tooth bending stresses are low — around 50,000 psi.

To order Paper No. 208C . . .
from which material for this article was drawn, see p. 6.

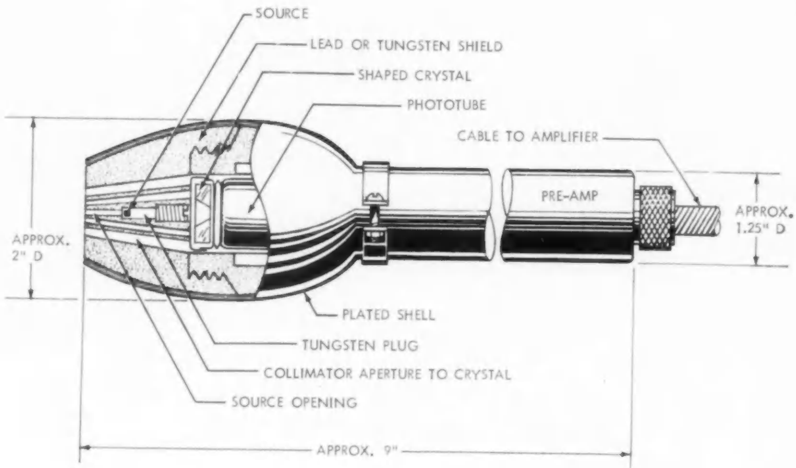


Fig. 1 — **Probe assembly with collimated focus on axis.** This device can detect a 5% change in shape or contour of an object ⅛ in. in diameter.

Radioisotopes check machining operations

Based on paper by

J. H. Tolan, Lockheed Aircraft Corp.

A TWO-DIMENSIONAL CUTTING OPERATION was aborted recently, when one motion jammed and the other continued. Result: the cutting tool chewed through the workpiece . . . and then through the table in a kind of automated hara-kiri.

An adaptation of the backscatter technique explored by Lockheed Nuclear Products for the Atomic Energy Commission may provide suitable controls to prevent just such difficulties and consequences. And it may be able also to control the contour of screwthreads during grinding, measure the dimensions and location of internal cuts, and measure the wall thickness of bored openings in castings.

Fig. 1 illustrates a typical probe intended for measure of change in shape or contour. In this design, radiation is emitted through a restricted opening to the object being measured. Then, depending on the size and location of the object, a focused collimator admits some of the scattered radiation back to the crystal detector. The expected defect sensitivity of such a probe is to detect changes in shape or contour of 5% of an object cross-section ⅛ in. in diameter.

A suggested application of this probe configuration is shown in Fig. 2, which illustrates a monitor for control of a cutting tool. The probe can be made insensitive to its environment and not be affected by oil vapors, high temperature, vibration, or other factors influencing instrument response. It will not measure thickness of the machined piece within usual dimensional tolerances, but it will monitor the position of the cutting tool relative to the work and respond to any unwanted variation in relative position.

Another potential application for this probe is illustrated in Fig. 3. Here, the grinding of threads on a lead screw is monitored by viewing the thread contour and measuring its relative size, shape, and position. Again, an absolute dimensional measure is not attempted. But if the instrument is initially calibrated on a standard section of the thread, any variation in size, shape, and position either singly or in combination can be detected.

It is also possible to direct the radiation so that the focus location is normal to the probe axis. Such an arrangement is shown in Fig. 4. Radiation emerges from the collimator to impinge on the scattering material at a predetermined distance. Scatter from this volume is admitted to the detector through the open channels of the focused collimator.

One application of this probe is shown in Fig. 5, in which an internal machine cut is inspected for width, depth, and position of cut. In the diagram, the internal cut is a helical keyway held to close dimensional tolerance. Resolution of the radiation beam is fine enough to permit a rapid inspection of such machined contours.

Another application shown in Fig. 6 depicts the measure of concentricity of a hole bored in an engine block or similar casting. Such a device is an important aid where inner passages occur within the casting, such as in a water cooling channel. Casting flaws may be detected also by scanning from within the bored hole.

To Order Paper No. 181C . . .
from which material for this article was drawn, see p. 6.

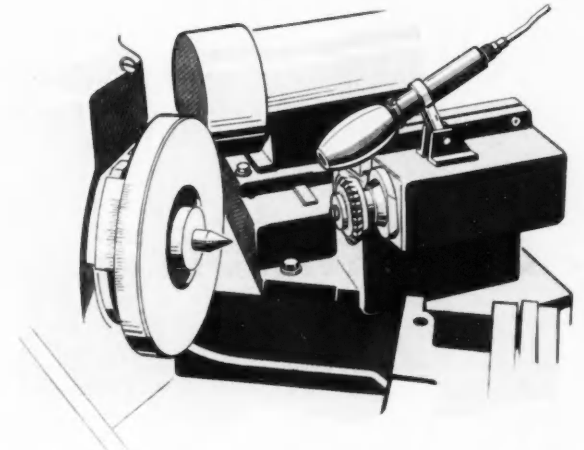


Fig. 2 — **Monitor for control of cutting tool.** Device monitors the position of the cutting tool relative to the work and responds to any unwanted variation in relative position.

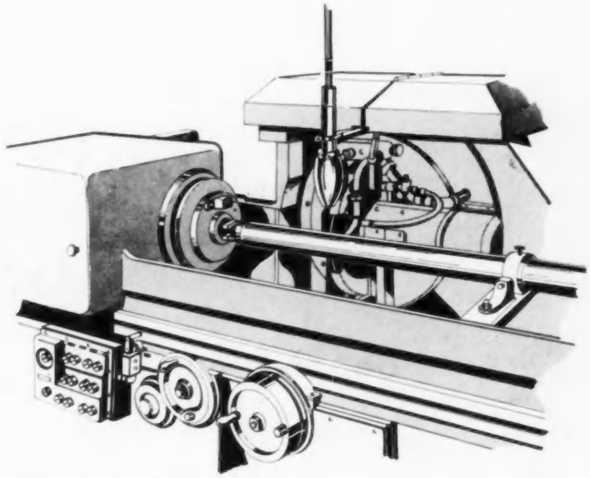


Fig. 3 — **The grinding of threads on a lead screw** is monitored by viewing the thread contour and measuring its relative size, shape, and position.

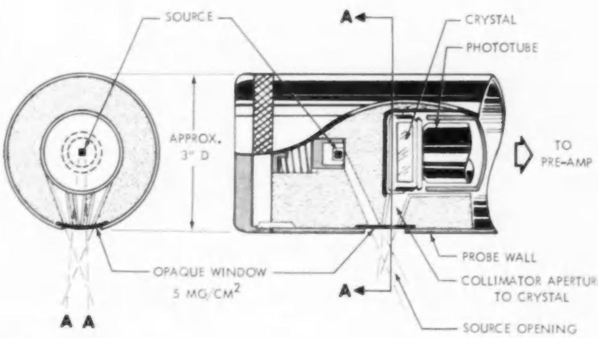


Fig. 4 — **Probe assembly with collimated focus at right angle to axis.** Radiation emerges from the collimator to impinge on the scattering material at a predetermined distance. Scatter from this volume is admitted to the detector through the open channels of the focused collimator.

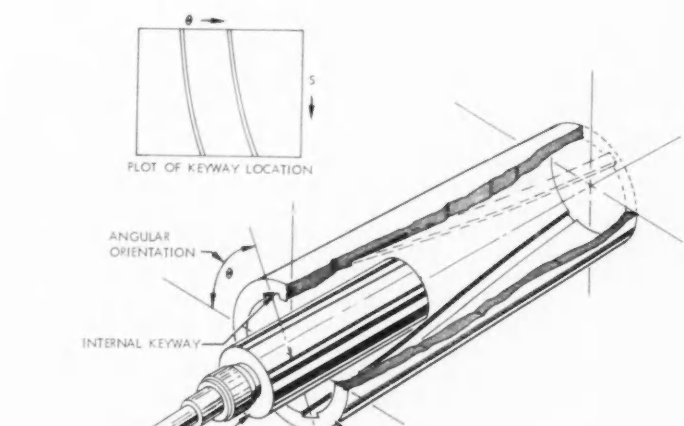


Fig. 5 — **Internal machine cut is inspected for width, depth, and position of cut** by probe assembly with collimated focus at right angle to the axis.

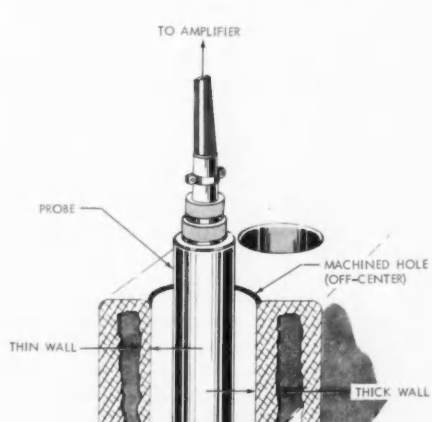


Fig. 6 — **The concentricity of a hole bored in an engine block or similar casting** can be measured by a collimated focus at right angle to axis.

occurrence of

Surface Ignition

depends on:

- **Surface temperature.**
- **Local air-fuel ratio.**

Based on paper by

F. W. Bowditch and T. C. Yu

General Motors Research Laboratories

SURFACE IGNITION — or the burning of a fuel-air mixture on contact with a hot surface in the combustion chamber — will occur when the following conditions are met simultaneously:

- Mixture is heated to above its ignition temperature.
- Mixture composition is within the limits of inflammability.

These conditions apply whether the surface consists of materials, like engines deposits, that consume oxygen during the ignition process of whether it is an inert, nonconsumable material. The detailed explanation of how surface ignition occurs does differ slightly, however, for the two types of surface.

Engine deposits

Fig. 1 shows how ignition takes place, according to the explanation, in the presence of engine deposits.

The important point to note is that, since the deposits themselves are consuming oxygen during surface ignition, the mixture adjacent to the deposits is being depleted of the oxygen needed to burn the mixture. In this case, the air-fuel ratio of the mixture next to the deposit surface may become so rich that it exceeds the limit of inflammability. Thus, if ignition takes place at all under these circumstances, it will do so only at a distance from the deposit surfaces, where the air-fuel mixture is within the flammability limits.

As we move away from the deposit surface, however, there is a gradual drop in temperature. So the temperature at the surface of the deposit must be somewhat higher than the required mixture ignition temperature to provide a high enough temperature at the point where the mixture is within the flammability limits.

All this is shown in Fig. 1. Note how the temperature of the mixture surrounding the deposit is assumed to decrease as the distance from the surface increases, until the average mixture temperature is reached.

Up to the distance X from the deposit surface, the air-fuel mixture surrounding the deposit is too rich to burn because the deposit has consumed too much of the local oxygen supply. At distances greater than Y from the deposit surface, the mixture is too cold to cause ignition. In the zone between distance X from the deposit surface and the distance Y, however, both the temperature and the air-fuel requirements for ignition are satisfied simultaneously, so that ignition should occur.

Hot spots

Fig. 2 shows the case where the surface causing the ignition does *not* consume any oxygen. Here, the mixture requirement for ignition is not important. Note that a temperature gradient will still exist in the immediate neighborhood of the surface as before. The air-fuel ratio will, however, now be independent of the distance from the surface. Therefore, as soon as the surface reaches the ignition temperature of the air-fuel mixture, as shown schematically in Fig. 2, ignition will occur right at the surface.

There are a number of complicating effects that have thus far been ignored. For instance, CO_2 and N_2 can have a very substantial effect on the limits of inflammability. Also, information on the effect of mixture ratio on the ignition temperature is not complete. Our own investigations, as well as those of others, have shown that mixture ratio has a negligible effect on hot-wire ignition tempera-

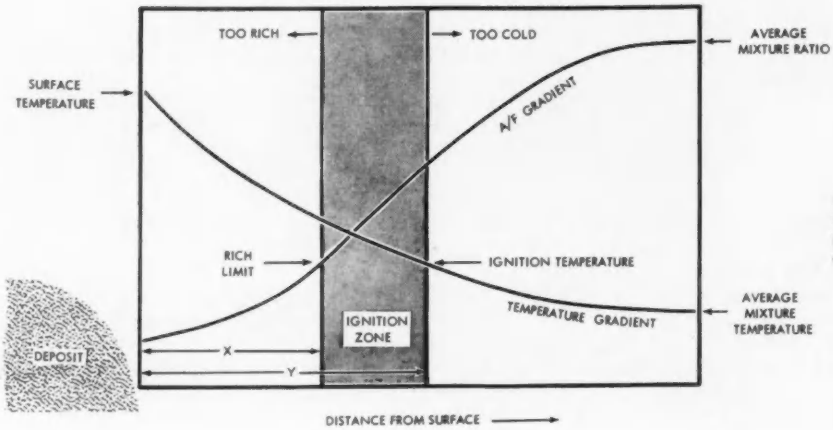


Fig. 1 — Chart showing how ignition takes place, according to the proposed theory, in the presence of engine deposits.

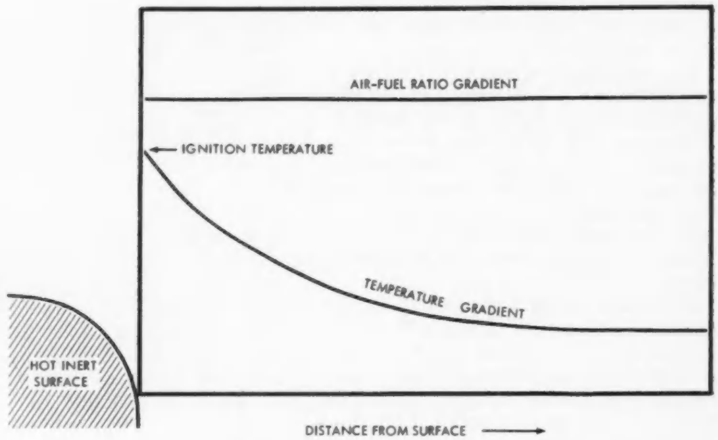


Fig. 2 — Chart showing how ignition takes place, according to the proposed theory, where the surface causing the ignition does *not* consume oxygen.

THE MECHANISM of ignition by hot surfaces in the combustion chamber, whether caused by deposits or hot spots, is not well understood. This is not surprising, for the ignition mechanism of spark knock, which has received considerably more attention, has not yet been completely explained.

Nevertheless, the problem of deposit ignition in today's automotive engines is one of serious proportions, for such abnormal combustion phenomena as preignition, wild ping, and rumble seem to have their origins in deposit ignition.

The authors of this article made a comparison of the ease of ignition, in an operating engine, of various fuel-air mixtures by both engine deposits and hot wires. From the results of this study, an explanation of deposit ignition was developed. It is based on the assumption that the fundamental surface ignition process is the same, no matter what the surface is like.

Their theory, the authors show, is adequate to explain their own verifying experiments (see complete paper) and also most of the experimental data reported in the literature.

Surface Ignition

. . . continued

ture for the range of mixture ratios commonly encountered in operating engines. However, whether this finding can be extended to the limits of inflammability has not been determined.

It has been known for a number of years that some surfaces are catalytic and conducive to certain surface reactions. As an example, Coward and Guest found that platinum wire, though very active catalytically, required a higher temperature to ignite fuel-air mixtures than a surface of equal dimension but of lesser catalytic action. On the other hand, when a cold jet of hydrogen and oxygen mixture was allowed to stream over cold platinized asbestos, the asbestos became red hot and ignition of the mixture followed.

The explanation applied to this set of seemingly contradictory facts was that surface reaction reduced the availability of the fresh mixture near the surface of the platinum wire. Consequently, the temperature required for ignition was increased. In the case of platinized asbestos, however, since the heat conductivity is poorer than that of platinum wire, the platinized asbestos material attains higher surface temperatures and ignition is more likely to occur.

It is interesting to note the similarity of this explanation with the present explanation of deposit ignition where oxygen near the deposit surface is consumed by the combustion of the deposit, and as a result, gas-phase ignition occurs at some distance from the deposit surface.

Catalytic surface reactions probably also occur during the ignition process by hot surfaces in operating engines. This type of reaction exerts considerable influence on surface temperature and local mixture air-fuel ratio. However, when these two factors have been duly considered as they are in the proposed theory of surface ignition, the principal effects of catalytic surface reaction on ignition are taken into account.

There is another area in which surface reactions might have influence on surface ignition. That is the possibility that surface reactions may produce reaction products with lower ignition temperatures than the parent hydrocarbon. At present we know of no way to evaluate this possibility.

Combustion movies

Of the various experiments performed to find out if the theory actually jibes with fact, one of the most interesting included the use of combustion movies to verify the deduction that the point of ignition is, indeed, dependent on the amount of oxygen the igniting surface consumes. These high-speed movies were taken of the ignition processes caused by inert and engine-deposit surfaces in an operating engine. The inert surface was a U-shaped chromel A wire mounted as a glow plug and heated electrically. The oxygen-consuming surface was a ¼-in. diameter by 5/16 in. long pellet made of engine deposit and was attached to the combustion-chamber wall by a small wire. The igniting surface was mounted midway between the intake and exhaust valves of the L-head single-cylinder engine used in all the tests.

Fig. 3 shows six consecutive frames from the high-speed movies taken of hot wire and deposit ignition. The glowing U-shaped hot wire is clearly visible in the upper photographs and ignition of the fuel-air mixture is seen to take place in the frame marked X.

The lower photographs show the burning deposit pellet with ignition of the gaseous mixture barely visible in the frame marked Y. The deposit-ignition photographs are not as sharply defined as the hot-wire-ignition ones because the burning engine deposit rapidly coated the quartz window with a thin layer of lead salts before photographs could be taken.

As can be seen in frame X, hot-wire ignition took place at or very close to the wire surface; however, as shown in frame Y, ignition occurred at a distance from the deposit surface — the distance in this case being about 1/16 in.

Predicting surface-ignition resistance of fuels

Table 1 shows the deposit-ignition resistance, the hot-wire ignition resistance, and the rich limit information for the six fuels for which complete data are available. Relative rankings are shown, "1" being the fuel with the greatest ignition resistance and "6" being the one with the least resistance. If the ignition source (chromel wire) used in determining the hot-wire ignition temperature is assumed to be inert, the hot-wire ignition temperature is equivalent to the ignition temperature. It may be assumed, therefore, that the hot-wire ignition resistance is directly related to the ignition temperature.

The values for rich limit shown in the table comprise the limit in terms of the per cent of stoichiometric air-fuel ratio. The numbers in parentheses represent the rankings of the fuels only on the basis

Table 1 — Relative Rankings of Fuels Based on Deposit-Ignition Resistance, Hot-Wire-Ignition Resistance, and Rich Limit

Fuels	Relative Ranking		Rich Limit, % Stoichiometric A/F Ratio
	Deposit-Ignition Resistance	Hot-Wire-Ignition Resistance	
2,2 dimethylbutane	1	4	28.5 (4)
Isooctane	2	3	27.8 (5)
Toluene	3	1	31.0 (2)
Benzene	4	5	29.8 (3)
Propane	5	2	35.3 (1)
Ethylene	6	6	16.4 (6)

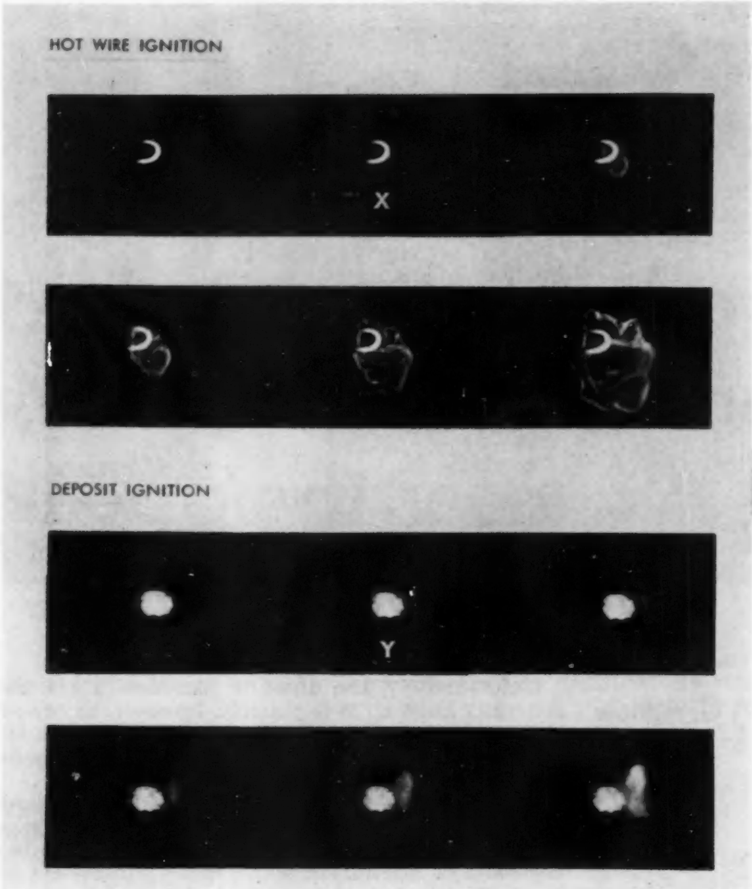


Fig. 3 — High-speed flame photographs of ignition processes by hot wire and engine deposits.

of the rich-limit information (shown with "1" again representing high resistance and "6" low resistance).

Combined consideration of the rankings shown under hot-wire ignition resistance and rich limit should, ideally, predict the ranking shown under deposit-ignition resistance. In the actual case, however, the correlation is not always consistent. For instance, 2,2 dimethylbutane has intermediate resistance to hot-wire ignition (ranking of 4) and also an intermediate rich-limit ranking (4). A consideration of these two rankings predicts an intermediate deposit-ignition resistance rather than the high resistance it is shown to have. Of the remaining five fuels, toluene, benzene, and ethylene predictions are reasonably good while isooctane and especially propane predictions are poor. The reason for the failures is not clear. Perhaps the effects of dilution and temperature on the rich limit, not considered in the correlation, are responsible.

As mentioned previously, H_2O, CO_2, and other inert gases have a substantial effect on the flammability limits of many fuels. The effect of dilution is to narrow the flammability limits. The rich limit of a fuel is changed in the presence of diluents; therefore, dilution would be expected to have a substantial influence on the deposit-ignition resistance of fuels.

For most mixtures, it has been shown that there is a straight-line relation between the limit of inflammability and the mixture temperature. The flammability limits widen with increasing temperature. If this factor is taken into account, the ranking of the fuels shown in Table 1 may also change considerably. For example, propane has a very high ignition temperature; that is, a ranking of 2 under hot-wire ignition resistance. Therefore, the rich limit of propane at the ignition temperature would be expected to be considerably richer than that shown in Table 1. This would lower its predicted deposit-ignition resistance and would make its ranking more consistent with the data shown in Table 1.

While it is realized that both dilution and temperature must be considered in connection with the rich limit, unfortunately, sufficient information is not available to permit a proper evaluation of these factors. Consequently, it is not possible at present to resolve whether the proposed ignition theory is sufficient to explain the differences in ignition resistances of fuels. However, it is to be noted that the theory can be used to explain some otherwise unexplainable experimental facts. It is our belief that it is worthy of serious consideration despite the lack of positive confirmation here.

To Order Paper No. 201A . . .
from which material for this article was drawn, see p. 6.

Two-wavelength infrared radiation method measures end-gas temperatures near their peak

Based on paper by

W. G. Agnew

General Motors Research Laboratories

ENGINE END-GAS TEMPERATURES can be measured with "reasonable" accuracy by the two-wavelength infrared emission method, General Motors studies show. This method perhaps gives the most significant results for knock studies, since it tends more than other methods to show the temperature of the hottest gas—which must eventually be first to reach spontaneous ignition in the engine cycle.

The technique uses a prism spectrometer, lead sulfide photoconductive detector, and electronic apparatus necessary to obtain statistical averages of the radiation signal emanating from the engine cylinder gases over a number of engine cycles.

Ratio of emission intensities at two near-infrared wavelengths is determined for particular crank-angles in a point-by-point manner, and with a suitable prior calibration the gas temperature is calculated from the intensity ratio.

Water vapor in the cylinder gases—either naturally present in the fresh intake air or remaining in the residual gas from prior fired cycles—serves as a source of radiation.

Two-wavelength principle

The two-wavelength radiation technique relies on the fact that the intensity of radiation from any material in thermal equilibrium varies with the temperature.

If the absolute emissivity of the material at some wavelength were known, and if the instrumentation were arranged so that absolute measurements of radiant energy were possible, then a simple measurement of the radiant energy emitted at one wavelength would determine the temperature.

Unfortunately, the absolute parameters are not generally known. It is possible, however, to cancel the need for many of these parameters, and reduce the influence of others if measurements are made at two wavelengths rather than at one.

The fact that radiation intensity is a different function of temperature at different wavelengths makes it possible to determine temperature from the ratio of intensities, while many parameters of the optical and electronic measuring system cancel out.

Two parameters, the emissivity of the radiator and the sensitivity of the detector, do not actually cancel, but at least absolute values for these factors are not needed, only their ratios at the two wavelengths. These ratios may be determined by empirical calibration.

The two wavelength radiation technique may be expressed from the fundamental laws of radiation as follows:

$$\frac{I_1}{I_2} = \frac{\epsilon_1}{\epsilon_2}\left(\frac{\lambda_2}{\lambda_1}\right)^5 \frac{\left(e^{\frac{C_2}{\lambda_2 T}}\right) - 1}{\left(e^{\frac{C_2}{\lambda_1 T}}\right) - 1} \qquad (1)$$

where I = radiation intensity of a substance at λ

ϵ = emissivity of the substance at λ

λ = wavelength of radiation

C_2 = Planck's second radiation constant

T = absolute temperature.

This relationship is obtained from Planck's equation for a perfect blackbody, and it applies to any radiating substance in thermal equilibrium.

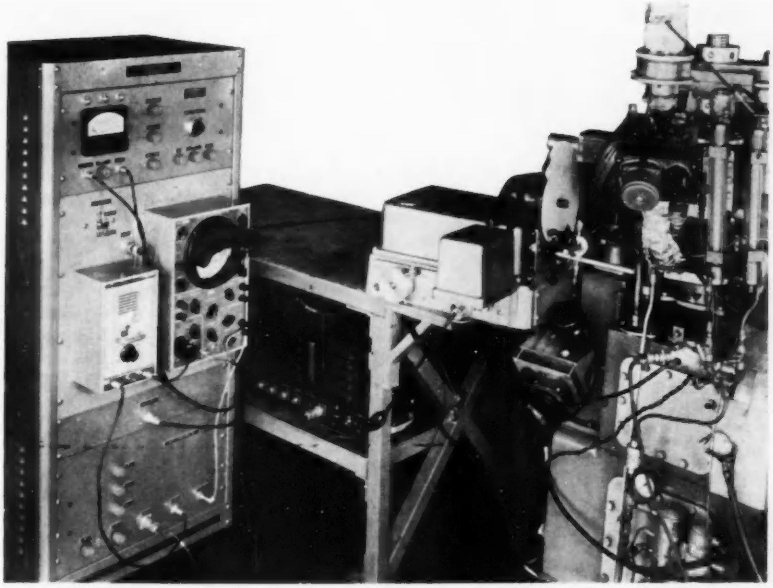


Fig. 1 — Equipment for two-wavelength temperature measurement.

The calculable blackbody part of Equation (1) may be expressed as:

$$\frac{B_1}{B_2} = \left(\frac{\lambda_2}{\lambda_1}\right)^5 \frac{\left(e^{\frac{c_2}{\lambda_2 T}}\right) - 1}{\left(e^{\frac{c_2}{\lambda_1 T}}\right) - 1} \qquad (2)$$

where B_1/B_2 is the ratio of emissive powers at the two wavelengths λ_1 and λ_2 for a black body at temperature T. At fixed wavelengths B_1/B_2 is a function of temperature only. The instrument constants may be taken care of by:

$$I = \frac{D}{K} \qquad (3)$$

where D is the output of the detector and K is the relative sensitivity of the detection system at λ.

The working relation below is obtained from equations 1, 2, and 3.

$$\frac{B_1}{B_2} = \frac{D_1}{D_2}\frac{K_2}{K_1}\frac{\epsilon_2}{\epsilon_1} \qquad (4)$$

If K_2/K_1 and ϵ_2/ϵ_1 are known by prior calibration, and if D_1/D_2 is measured, then B_1/B_2 may be determined. The known relation between B_1/B_2 and T (Eqn. 2) then permits determination of the absolute temperature of the radiating substance.

In this work water vapor present in the engine cylinder gases was taken as the radiating substance, and the wavelengths chosen were those of two water vapor bands at $\lambda_1 = 1.89$ and $\lambda_2 = 2.55$ microns. The blackbody relationship (Eqn. 2) was readily manipulated with the aid of a blackbody radiation slide rule.

Advantages

In principle, the two-wavelength method of temperature measurement has several advantages over the other methods currently in use. The problems of the sound velocity method associated with cooling of the measured gases by the cooled sound probes, and the uncertain effects of preflame reactions on the sound velocity are entirely absent. Turbulence of the end-gases, which may interfere with the sound velocity measurement, should have no effect on the two-wavelength method.

The two-wavelength method requires only one window in the engine combustion chamber instead of two, as required by the emission-absorption method, and presumably there is no direct effect of dirtying the engine window on the temperature measurement, as long as sufficient radiation passes to obtain the measurement. The emission-absorption method suffers a direct error from any dirt deposited on the windows between calibration and measurement.

Since all three of the end-gas temperature measurement techniques now in use involve an appreciable volume of gas, the matter of temperature gradients within the measured volume is of some concern. All three measuring techniques obviously give some sort of an average temperature for the gases under study. The actual temperature gradients existing in an engine are unknown. But it may be presumed that late in the compression stroke the bulk of the gas is at a temperature much higher than the cylinder walls, and that this bulk of gas is surrounded by a layer in which the temperature gradually decreases to the value at the wall.

Theoretical calculations indicate that while the sound velocity technique tends to give a temperature corresponding closely to the mass average temperature of the gases between the probes, the infrared emission-absorption method tends to give values closer to the peak temperature in the volume under observation.

The two-wavelength method of temperature measurement tends to give an average value still closer to the peak than the emission-absorption method. Thus, the two-wavelength method perhaps gives the most significant results for knock studies, since it tends more to indicate the tempera-

Two-wavelength infrared radiation method measures end-gas temperatures near their peak

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ture of the hottest gas which must eventually be first to reach spontaneous ignition in the engine cycle.

Of course, if the correlation of end-gas temperature with average cylinder pressures or heat transfer through the chamber walls is of interest, then a mass average temperature might be considerably more useful.

Equipment

Fig. 1 shows the equipment for two-wavelength temperature measurement. At the right is the single-cylinder research engine; in the center is the spectrometer for detecting radiation from the engine cylinder gases; and at the left is the Engine Radiation Ratio Indicator.

Fig. 2 shows the sandwich-head engine combustion chamber with the piston at top center and illustrates the viewing windows, the end-gas pocket, the spark plug, and the two instrument access holes.

Air is supplied to the engine either from the atmosphere or from the building compressed air lines through a critical flow air-metering system. The latter system provides a relatively constant, low humidity of about 0.25% H_2O by weight.

Air temperatures are controlled with an immersion electric heater in the surge tank ahead of the carburetor and electric heating tape wrapped around the intake manifold between the carburetor and the engine inlet valve.

Inlet mixture temperature is indicated by an unshielded immersion thermocouple just ahead of the inlet valve in the manifold.

The exhaust temperature, under motored conditions, is measured by an unshielded thermocouple in the exhaust port about one-half inch from the exhaust valve.

Liquid fuel flows are measured with calibrated rotameters, propane flow by a critical flow metering system. Exhaust back pressure is varied with a gate valve in the exhaust manifold.

Performance measurements on this engine showed no unusual effects attributable to the sandwich combustion chamber design. The maximum IMEP at 2000 rpm was 150 psi; MBT spark advance was 31 deg at 2000 rpm; and the primary reference blend octane requirement at this condition was 98.

Ionized-gap measurements of flame arrival time indicated that the end-gas pocket was actually one of the last parts of the chamber to be reached by the flame.

The flame arrived in the pocket about 50 crankangle degrees after ignition at the 2000 rpm maximum power condition. Cyclic variation of the arrival time was on the order of ± 3 to 5 crankangle degrees.

Optical System — Radiation from the end-gas pocket in the engine combustion chamber passes out through one of the 3/8-in. diameter by 3/16-in. thick quartz windows (the other window is not used for this work) and is focused on the spectrometer entrance slit by a quartz lens. The optical path length between the two end-gas windows is 2-7/8 in. The focal points of the lens are in the center of the engine end-gas pocket and at the spectrometer entrance slit.

A rotating shutter between the lens and spectrometer is driven by a selsyn sytem operated from the engine camshaft. The shutter interrupts the radiation beam for one complete engine revolution, starting to close 32 deg ATC on the power stroke and reaching full-open 47 deg ATC on the induction stroke. The purpose of this shutter is to provide a zero baseline for radiation on the detector and to prevent the extremely intense hot flame emission from reaching the detector and either changing its sensitivity characteristics or overloading the electronic circuits.

Between the shutter and the spectrometer slit is a multiple-wedge adjustable radiation attenuator. This optical attenuator is used to maintain a more or less constant level of illumination on the radiation detector under the different operating conditions, thus keeping the detector always in the linear portion of its operating range. The attenuator calibration also gives a measure of the relative signal intensity under the various operating conditions.

The detector signal from the hot flame radiation in the combustion chamber under some conditions is 500 times that from the unburned gases ahead of the flame front. Some of this radiation may reflect several times from various surfaces in the combustion chamber. If even a small portion of this radiation somehow manages to enter the optical system before the hot flame actually reaches the window, it could interfere seriously with measurements of the unburned gas. Therefore, attempts were made to determine whether such interference does occur.

A tungsten lamp was placed at various positions in the chamber, and the amount of radiation enter-

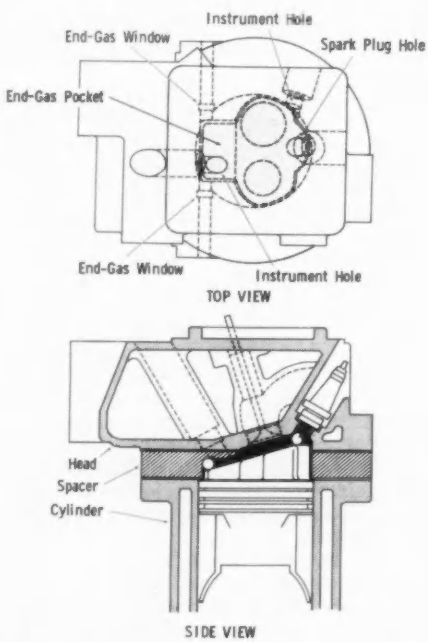

Fig. 2 — Sandwich-head engine combustion chamber with piston at top center.

ing the spectrometer was measured. When the lamp was ¼ in. away from the line of sight through the end-gas windows, the signal on the detector was reduced to about 1/100 of its direct value. This means that at this distance the reflected hot flame radiation may still be about five times stronger than the unburned gas radiation. Unfortunately, a light source as intense as the hot flame could not be conveniently placed in the engine, so it could not be determined at what distance a source of this strength would produce a negligible signal.

It can only be concluded that the hot flame probably affects the temperature measurements when it is within ¼ in. of the windows, and very likely does not affect the measurements when it is near the spark plug at the far side of the combustion chamber.

Spectrometer — The spectrometer is a Perkin-Elmer Model 99 double-pass monochromator with a lithium fluoride prism and lead sulfide detector. The slits were kept at 2000 microns — a width necessitated by the extremely low radiation intensities involved. The internal 13 cps chopper is not used, and single-pass radiation, which was found to interfere seriously with the measurements, is eliminated by masking portions of the spectrometer slits. The masking does not reduce the signal intensity appreciably, since only about one-third of the slit length is illuminated anyway.

In early work atmospheric air was allowed in the spectrometer, but it was later suspected that variations in atmospheric humidity were affecting the temperature measurements by varying the amount of self-absorption in the water vapor bands. From then on the spectrometer was flushed continuously with nitrogen. Much of the day-to-day variation in results appeared to be eliminated.

Detector — A Kodak Ektron lead sulfide cell with a time constant of about 800 microsec was found to be best.

Engine Radiation Ratio Indicator (*ERRI*) — Its purpose is to permit the determination of the mean value (with respect to engine cyclic variations) of the detector signal voltage ratio at the two wavelengths. Briefly, it functions as follows: The signal from the spectrometer detector, which varies with time in the engine cycle, is compared with a reference voltage level at any given instant during the engine cycle. The instant of comparison is determined by a pulse from a pulse generator which can be manually adjusted to any desired crank angle. A coincidence meter reads the percentage of cycles in which the engine signal voltage is greater than the reference level at the predetermined crank angle (thus "averaging" the engine cyclic variations).

In use, the spectrometer is set to the wavelength of the weaker radiation (1.89 microns); the reference voltage level is adjusted for 50% coincidence at the desired crank angle (the reference level thus represents the mean cycle-to-cycle signal voltage); the spectrometer is then adjusted to the wavelength of the stronger radiation (2.55 microns), and this detector signal is electrically attenuated by means of a potentiometer to again give 50% coincidence. The fraction of attenuation required is equal to the ratio of the first signal to the second, and this fraction is read directly from the potentiometer dial. The dial is graduated in ten turns with 100 divisions for each turn. Thus, the signal ratio can be read directly to three significant figures. In the range of ratios used, 0.060 to 0.200, one division on the dial corresponds to about 5 F.

Radiation from the engine

Spectra—Fig. 3 indicates the types of radiation spectra obtained from the engine under typical motoring and firing conditions. Each spectrum represents the peak intensity of the unburned gas radiation plotted as a function of wavelength. The spectra are all plotted to the same scale. The two wavelengths of water vapor emission at which the intensity ratio is determined are indicated by vertical lines along with the spectral slit widths resulting from the 2000-micron spectrometer slit.

The motored isooctane, benzene, and propane-air spectra have the lowest intensity; the motored air spectrum is slightly more intense at the water vapor wavelengths. The fired engine and the motored 80 octane primary reference blend spectra are considerably more intense because in these cases both the temperatures and the water vapor concentrations are higher. The water vapor content is higher in the fired engine because of residual dilution, and higher with the 80 octane fuel because of water production in the preflame reactions.

Of particular interest in Fig. 3 is the intense emission between 2.1 and 2.5 microns, which apparently comes from the unreacted fuel (and perhaps partly from preflame reaction products).

The spectral slit widths would seem to exclude this radiation from influencing the temperature measurements to any appreciable extent with isooctane, propane, and the primary reference blend. However, with benzene the fuel emission has a different distribution and it might be expected that the intensity reading at λ_2 (second wavelength) = 2.55 microns would be somewhat increased by the fuel emission, thus tending to make the temperature readings somewhat lower than would otherwise be

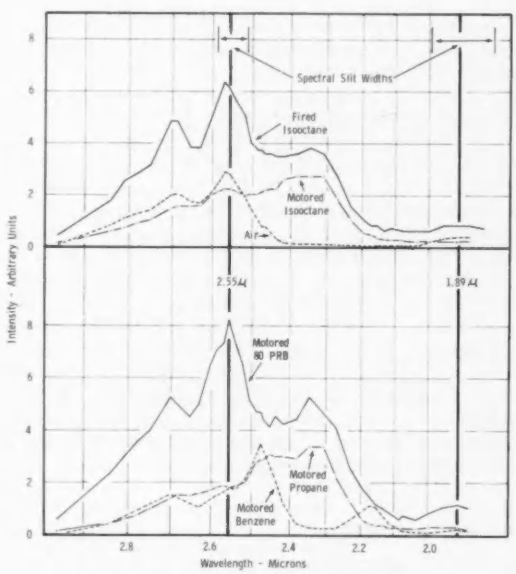

Fig. 3 — Engine unburned gas emission spectra.

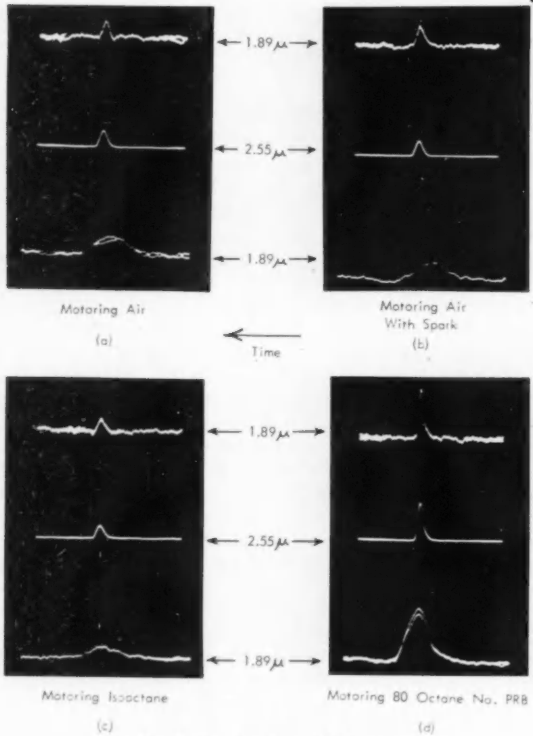

Fig. 4 — Motored engine radiation traces.

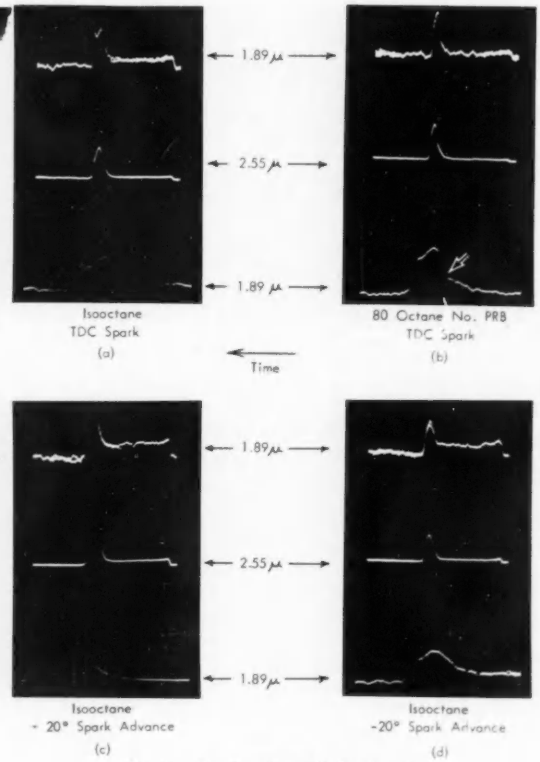

Fig. 5 — Fired engine radiation traces.

Two-wavelength infrared radiation method measures end-gas temperatures near their peak

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the case. No attempt was made to estimate the magnitude of this error.

Oscilloscope Traces—Figs. 4 and 5 show a number of radiation traces photographed from the oscilloscope face during motoring and firing operation respectively. In each of these traces time progresses from right to left, and in the top two traces of each photograph the length of the trace corresponds to one engine cycle or 720 deg of crank angle. In most cases only a single engine cycle is recorded, although in some exposures portions of a second cycle appear. The top trace represents the radiation at 1.89 microns as it was presented for temperature measurement. The middle trace represents the radiation at 2.55 microns attenuated as it was for temperature measurement (the attenuation was on the order of 1/10). The lowest trace represents again the radiation at 1.89 microns, but this time with the horizontal scale expanded.

Accuracy and precision

The absolute accuracy of this temperature measuring technique is not known and probably cannot be known with certainty. The accuracy of the temperature data given here depends on:

- The accuracy of the calculated gas temperatures for the motored air runs, which in turn depends on the accuracy of the pressure, airflow, and other measurements and also on the assumptions involved in the calculation;
- The accuracy of the assumption that the temperature on the end-gas, as averaged by the radiation technique in the motored-air case, is, in fact, represented by the calculated value (which requires that temperature gradients in the optical path be negligible with motored air); and
- The accuracy of the assumption that no additional factors become involved when measurements are made under conditions other than motored-air.

Since these factors may never be known for sure, perhaps it will be sufficient to rely on the "reasonableness" of the results obtained. This involves comparing the results with what might logically be expected from an engine and with results obtained by other independent, but perhaps equally uncertain, temperature measuring means. Attempts are made to check this "reasonableness" in the discussion of data to follow.

If accuracy eludes our grasp, certainly precision or reproducibility, can be pinned down. Experience has shown that three classes of precision can be distinguished in this work, as follows:

1. The precision with which a single temperature

reading could be made at one moment — i.e., the precision with which the ERRI attenuator dial could be set and read and a deviation from 50% on the coincidence meter was noticeable — was about ±5 F. This was essentially the reading precision of the instrument and included no allowance for drift in either the instrument or engine conditions.

2. The repeatability of readings for the same engine condition run from day to day or week to week with a motored engine was ±10–20 F. This variation is represented essentially by the scatter in the data on the individual curves shown later. It included the possibility of some drift in the instrument and engine operating conditions. This same precision existed for the fired engine in a given day's running.

3. The variation from day to day in the fired-engine studies, which included possible variations in ambient conditions, ranged up to ±50 F.

Reading precision and short term reproducibility of the two-wavelength technique for temperature measurement are of the same order as those for the sound velocity and emission-absorption techniques, but the latter methods do not seem to be troubled by the larger day-to-day variations noted here for the fired engine.

It is possible that the large day-to-day variations in end-gas temperature encountered here for the fired engine may have resulted from variations in ambient humidity and its effect on burning rates in the engine. Such effects seem to have been magnified by the generally retarded spark timing used, so that power differences from day to day, apparently due to humidity changes, were also noted.

Thus, it is quite possible that the ±50 F precision mentioned above represents actual variations in engine end-gas temperatures and should not be charged to the temperature measuring technique as errors.

Limitations

Limitations remaining with this temperature-measuring technique are concerned with the time at which radiation from the normal flame in the cylinder begins to interfere with the unburned gas temperature measurement, and the correction of the temperature readings for changes in optical depth under conditions of very high water vapor concentration. While neither of these problems is believed to have appreciably affected the general conclusions reached here, they remain as serious factors to be resolved in any future application of this technique.

Test results

With this technique, unburned gas temperatures have been shown to increase with increasing inlet temperature, coolant temperature, engine speed, spark advance, throttle opening, and exhaust back pressure, and with decreasing fuel octane number. End-gas temperature is a maximum near the maximum power fuel-air ratio and decreases for richer and leaner mixtures. In general, engine cylinder wall temperatures, as affected by the peak cycle temperature, appear to have a strong influence on end-gas temperature.

To Order Paper No. 201D . . .
from which material for this article was drawn, see p. 6.

Air Toilets Challenge To Designers' Ingenuity

Excerpt from paper by

HAROLD W. ADAMS
Douglas Aircraft Co.

THE TOILET SYSTEM installed in the Douglas DC-8 is a fine example of the problems of design, testing, development, and service-debugging of a complex system in a modern airplane.

While this system has no effect on the safety of an airplane, it can certainly delay takeoffs, if inoperative. It can, in fact, cause cancellation of a trip, should it become totally inoperative early in the flight.

On the DC-8, the decision was made to modernize the airplane by including flushing toilets. (That meant abandoning the old simple and reliable system of a bucket with a seat over it . . . which had already been complicated slightly by making it possible to service the bucket from outside the airplane.)

Since it was impractical, from a weight standpoint, to carry enough fresh water to flush the toilet, a filtering and recirculating system was used.

Right then, complication reared its ugly head. It became necessary, since the airplane has four toilets (two forward and two aft), to have at least two waste tanks, two sets of recirculating pumps and two sets of filters.

If four sets of everything had been used, the reliability would have been improved. There would be less probability of a single failure causing half the toilets to become inoperative. But the maintenance would have increased because of the larger number of parts requiring service.

Douglas designers compromised by using two waste tanks and filters per airplane, with four recirculating pumps . . . one for each toilet.

The system was developed and tested in an apparently thorough manner. But when it entered airline service, filters clogged in early flights, with consequent stalling of pumps and inoperative toilets. The toughness of the toilet paper procured by some airlines as compared with that used in the Douglas tests was a major cause of these cloggings. So, it would appear, one must obtain worldwide samples of toilet papers if one is to test such a system thoroughly for transports destined for worldwide service . . . or, for the tests, use a paper tougher than any that conceivably might be used.

To Order Paper No. 229B . . .
from which material for this article was drawn, see p. 6.

At Ford . . .

Computer predicts

Based on paper by

Henry L. Setz

Ford Motor Co.

PREDICTING the performance characteristics of vehicles before production is important to the automotive manufacturer. Previously, performance predictions depended upon long-hand solution of complex equations. Now, however, rapid, reliable, mechanized prediction methods are available that reduce solution time as much as 95%. Also, the repetitive process of design, build, and test that was often necessary to supplement the hand solution may now be greatly reduced. This article reveals how Ford uses computers to predict car acceleration.

Ford stipulates the desired characteristics for acceleration performance in the embryonic stage of passenger-car design. Specific objectives are selected for each of the following:

1. 0–4 Second Start-Up Distance. This is the distance traveled by a vehicle at wide-open-throttle during a 4-sec period after initial depression of the acelerator.

2. 0–10 Second Start-Up Distance. Same as above except for a 10-sec period.

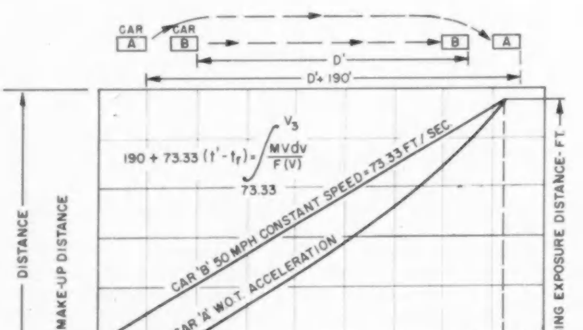


Fig. 1 — 50-mph passing exposure time — simulated passing maneuver.

3. 50 Mph Passing Exposure Time. This simulates a vehicle passing maneuver and is the time required at wide-open-throttle to accelerate the vehicle from 50 mph constant speed through a distance 190 ft greater than that traveled by a 50 mph constant-speed vehicle during the same time. Time is measured from initial depression of the accelerator from the 50 mph constant-speed position. The 190-ft make-up distance provides adequate vehicle spacing at 50 mph. While a downshift operation is included for cars with automatic transmissions, manual shift transmissions are appraised on the basis of high-gear operation. A graphical definition of this criterion is shown in Fig. 1.

Development of fundamental relationships

The problem of expressing acceleration performance criteria in terms of kinematics and engineering mechanics starts with the elementary concepts of motion and the natural laws which produce motion. From these concepts we can express the differential equations defining the translatory motion of a passenger car.

$$v = \frac{ds}{dt} \quad (1)$$

$$a = \frac{dv}{dt} = \left(\frac{dv}{ds}\right)\left(\frac{ds}{dt}\right) = \frac{vdv}{ds} \quad (2)$$

or:

$$ds = \frac{vdv}{a} \quad (3)$$

and:

$$dt = \frac{dv}{a} \quad (4)$$

where:

t = Time, sec
s = Distance, ft
v = Velocity, fps
a = Acceleration, fps^2

We must also consider the causes of motion and the associated concepts of force, mass, and acceleration. From Newton's laws of motion we get an expression which provides the link relating the ve-

car acceleration

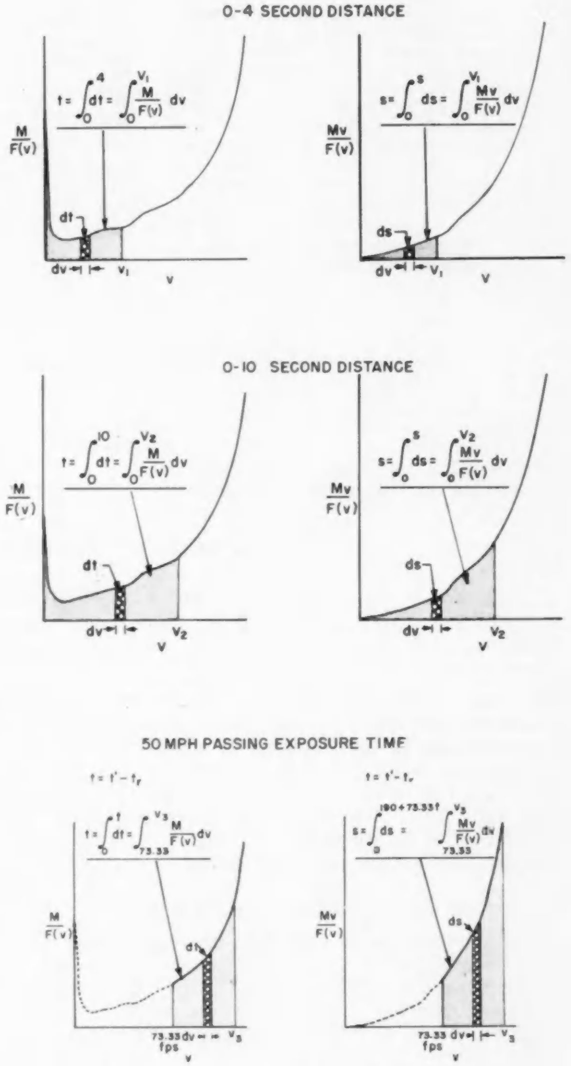


Fig. 2 — Integral evaluation — graphical description of 0–4 sec distance, 0–10 sec distance, and 50-mph passing exposure time.

hicle's translatory motion to its cause, the resultant or net driving force at the wheels.

$$F = Ma$$

or:

$$a = \frac{F}{M} \tag{5}$$

The value for acceleration from eq. (5) is substituted into eq. (3) and (4). F, the net driving force at the wheels, is a complex function of velocity and will be expressed as $F(v)$.

$$ds = \frac{vdv}{\frac{F(v)}{M}} = \frac{Mvdv}{F(v)} \tag{6}$$

$$dt = \frac{dv}{\frac{F(v)}{M}} = \frac{Mdv}{F(v)} \tag{7}$$

Vehicle start-up performance capabilities such as the 0–4 sec. and 0–10 sec. distances may be evaluated by integrating eq. (6).

$$\text{0–4 sec. distance } S = \int_0^s ds = \int_0^{v_1} \frac{Mvdv}{F(v)} \tag{8}$$

$$\text{0–10 sec. distance } S = \int_0^s ds = \int_0^{v_2} \frac{Mvdv}{F(v)} \tag{9}$$

The equation expressing the 50 mph passing exposure time, t^1, is formulated from the graphical definition of this criterion shown in Fig. 1.

$$190 + 73.33\, t^1 = \int_{73.33}^{v_3} \frac{Mvdv}{F(v)} + 73.33\, t_r$$

$$\text{or } 190 + 73.33\,(t^1 - t_r) = \int_{73.33}^{v_3} \frac{Mvdv}{F(v)} \tag{10}$$

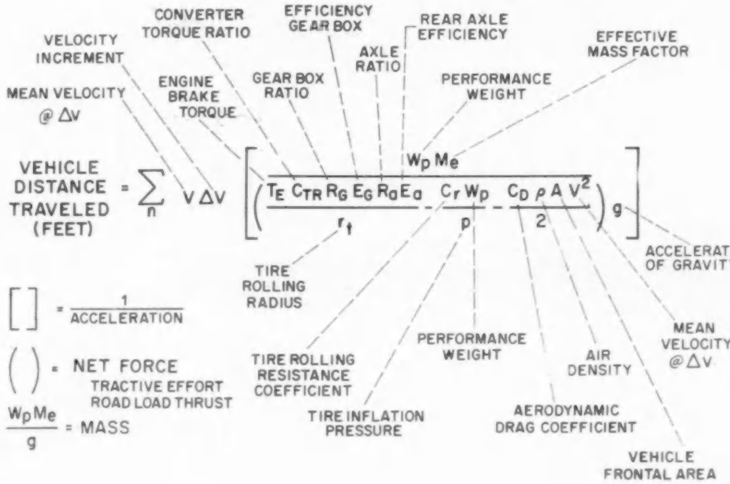
The respective integral limits v_1, v_2 and v_3 from eq. (8)–(10) must be evaluated before these integrations can be performed. The integration of eq. (7) for each performance criterion will accomplish this evaluation.

$$\begin{matrix}\text{0–4 sec. distance}\\ \text{limit evaluation}\end{matrix} = \int_0^4 dt = \int_0^{v_1} \frac{Mdv}{F(v)} \tag{11}$$

$$\begin{matrix}\text{0–10 sec. distance}\\ \text{limit evaluation}\end{matrix} = \int_0^{10} dt = \int_0^{v_2} \frac{Mdv}{F(v)} \tag{12}$$

$$\begin{matrix}\text{50 mph exposure time}\\ \text{limit evaluation}\end{matrix} = \int_0^{t^1 - t_r} dt = \int_{73.33}^{v_3} \frac{Mdv}{F(v)} \tag{13}$$

A graphical description of the method employed to evaluate the integrals expressed in eq. (8)–(13) is found in Fig. 2. The M/F and Mv/F functions of velocity are plotted as shown. Determination of



$$\text{VEHICLE DISTANCE TRAVELED (FEET)} = \sum_n V\Delta V \left[\frac{W_p M_e}{\left(\frac{T_E C_{TR} R_G E_G R_a E_a}{r_t} - \frac{C_r W_p}{p} - \frac{C_D \rho A V^2}{2}\right) g}\right]$$

Fig. 3 — Definition of general distance equation terms.

Computer predicts car acceleration

. . . continued

the area under the M/F function between limits prescribed for each criterion defines the respective upper limits for the integral of the Mv/F function. Subsequent determination of the areas under the Mv/F curves evaluates the respective integrals of this function. Eq. (8)–(13) represent all of the fundamental relationships required to express our acceleration performance criteria.

Evaluation of performance equations

The calculation of distance or time values from equations expressing performance criteria can be accomplished by either analog or digital computers. Problems requiring numerous repetitive solutions, such as those in the performance field, are best handled by the digital machine. Since the digital computer performs all mathematical operations by addition and subtraction, a numerical integration of the performance equations is required.

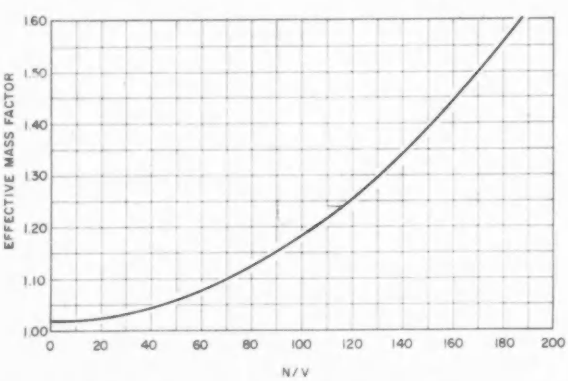


Fig. 4 — Effective Mass Factor is a factor used to express powertrain rotating inertias as a function of the translatory mass of the vehicle. Experimentally determined factors representing many different vehicles are plotted against N/V to construct a curve. The ratios of engine rpm to car speed are calculated for a specific vehicle, and corresponding values of effective mass factor are read from the curve and substituted in Eq. 20.

Numerical integration is a particular numerical summation process commonly employed to evaluate definite integrals of a complex nature. To perform this operation, a dependent variable is first selected and then subdivided into a large number of increments of definite magnitudes. The equation is numerically evaluated for each successive increment of the dependent variable. The incremental evaluations of the independent variable thus obtained are summed between prescribed limits to evaluate the integral.

Either time or velocity may be selected as the dependent variable for numerical integration of the performance equations. Since most of our powertrain characteristics are expressed as functions of velocity, we have selected velocity as the dependent variable. The magnitude of velocity increments selected for our computer solutions is 0.50 mph.

Since eq. (8)–(10) contain specific integrals representing vehicle distance, the general equation for distance will be employed to demonstrate the evaluation procedure.

$$\text{Vehicle distance traveled} = S = \int_{s_1}^{s_2} ds = \int_{v_1}^{v_2} \frac{Mvdv}{F(v)} \quad (14)$$

$$= \sum_n V \,\Delta V \left[\frac{M}{F(v)}\right] \quad (15)$$

where:

ΔV = Velocity increment
V = Mean velocity for each ΔV
n = Number of increments

Eq. (15) will now be expanded to incorporate significant vehicle and powertrain characteristics required to evaluate the summation. Note that all force terms resulting from the expansion are func-

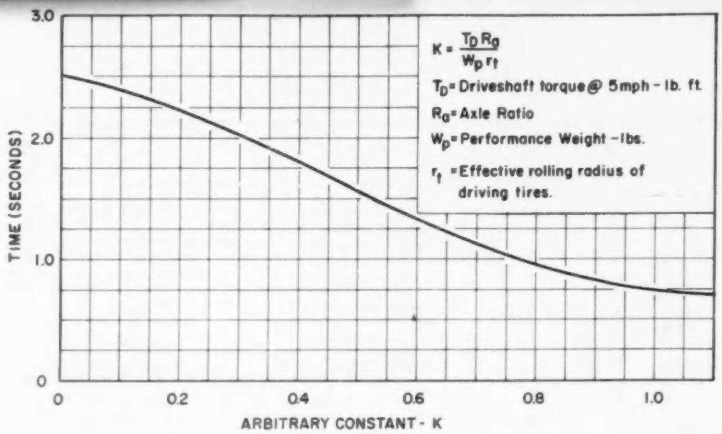


Fig. 5 — 0–10 Mph Time Curve is employed to express vehicle startup response characteristics empirically. The numerical integration of Eq. 20 is initiated from a vehicle speed of 10 mph when predicting 0–4 sec and 0–10 sec distances. The first velocity increment (0–10 mph) is evaluated from the curve, where 0–10 mph time is plotted as a function of an arbitrary constant K defined above. The curve represents an average of data compiled from tests of many passenger cars with automatic transmissions.

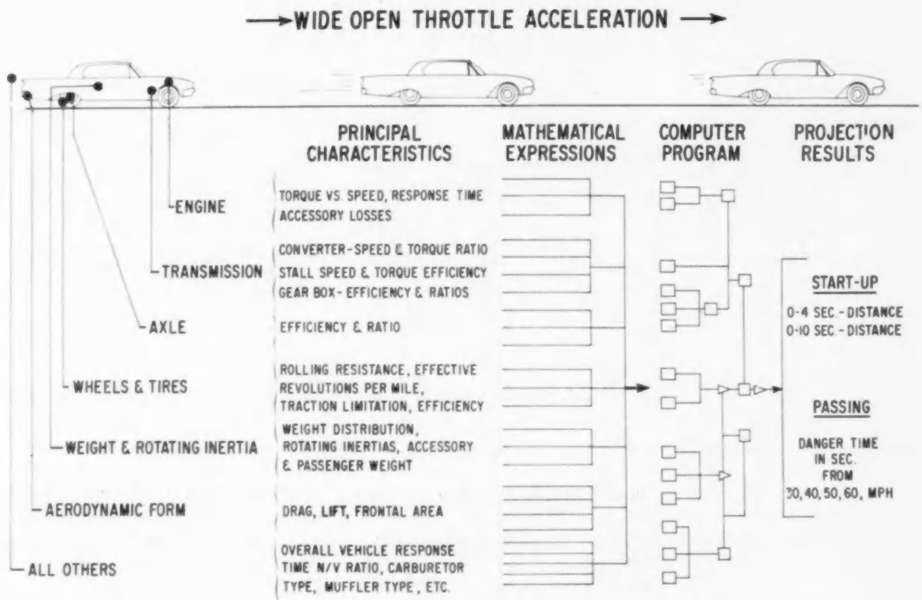


Fig. 6 — Computer solutions — general flow chart.

tions of vehicle velocity and are for vehicles with automatic transmission.

$$\text{Vehicle distance traveled, ft.} = \sum_n V\,\Delta V \left[\frac{\text{mass}}{\text{net force}}\right] \tag{15}$$

$$= \sum_n V\,\Delta V \left[\frac{\text{mass}}{\text{tractive effort–road load thrust}}\right] \tag{16}$$

where:

$$\text{Mass, slugs} = \frac{W_p M_e}{g} \tag{17}$$

$$\text{Tractive effort, lb} = \frac{T_E C_{TR} R_G E_G R_a E_a}{r_t} \tag{18}$$

$$\text{Road-load thrust, lb} = \frac{C_R W_p}{p} + \frac{C_D \rho A V^2}{2} \tag{19}$$

Substituting eq. (17)–(19) into eq. (16) and collecting terms, we have:
Vehicle distance traveled =

$$\sum_n V\,\Delta V \left[\frac{W_p M_e}{\left(\frac{T_E C_{TR} R_G E_G R_a E_a}{r_t} - \frac{C_r W_p}{p} - \frac{C_D \rho A V^2}{2}\right) g}\right] \tag{20}$$

A brief definition of terms for eq. (20) is shown in Fig. 3. The group of terms expressing net driving force is a complex function of velocity. These terms are expressed in the form of empirical curves constructed from test data or as predicted curves.

Effective Mass Factor (Fig. 4) is a factor used to express powertrain rotating inertias as a function of the translatory mass of the vehicle. Experimentally determined factors representing many different vehicles are plotted against N/V to construct the curve shown in Fig. 4. The ratios of engine rpm to car speed are calculated for a specific vehicle, and corresponding values of effective mass factor are read from the curve and substituted into eq. (20).

0–10 mph Time Curve (Fig. 5) is employed to express vehicle start-up response characteristics empirically. The numerical integration of eq. (20) is initiated from a vehicle speed of 10 mph when predicting 0–4 sec. and 0–10 sec. distances. The first velocity increment (0–10 mph) is evaluated from the curve, where 0–10 mph is plotted as a function of an arbitrary constant K defined in Fig. 5. The curve represents an average of data compiled from tests of many passenger cars with automatic transmissions.

Engine speed–car speed relationships must be ac-

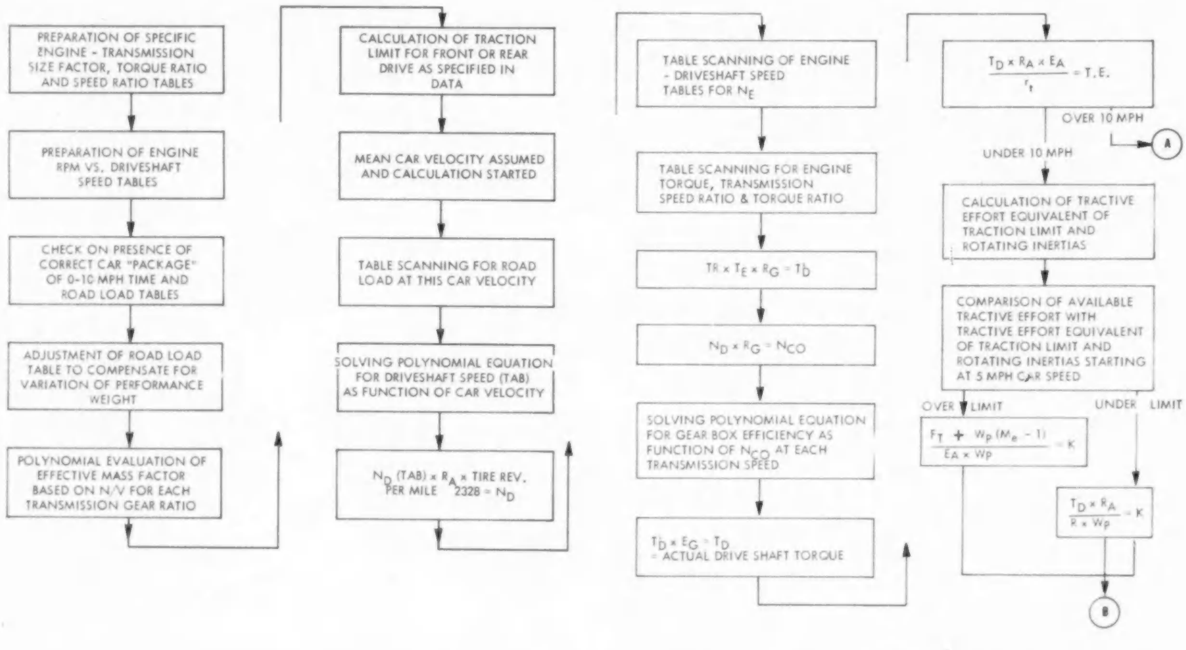


Fig. 7 — Car acceleration performance calculation — powertrain equipped with automatic transmission —

Computer predicts car acceleration

. . . **continued**

curately determined to express the net driving force function of vehicle velocity correctly. The precise definition of this relationship is complicated by converter slip and the effective slip or creep between the driving tires and the road surface. Compatibility between net driving force terms from eq. (20) and the mean velocity of each increment evaluated is achieved by a driveshaft speed matching technique.

Vehicle acceleration with spinning drive wheels occurs when the tractive capacity of the driving wheels is exceeded by the tractive force transmitted by the powerplant. The acceleration magnitudes associated with spinning drive wheels are limited by the available traction at the road surface. The evaluation procedure for the numerical integration of distance includes a technique for imposing a tractive limit.

Evaluation of vehicles with manual-shift transmissions

The procedure previously outlined pertains to the prediction of acceleration performance for passenger cars with automatic transmissions. The prediction of performance for manual-shift-transmission vehicles require the following changes:

1. Elimination of equation terms describing the torque converter.
2. Deletion of the procedure for matching the engine and torque converter.
3. Substitution of appropriate manual-shift-transmission vehicle input data.

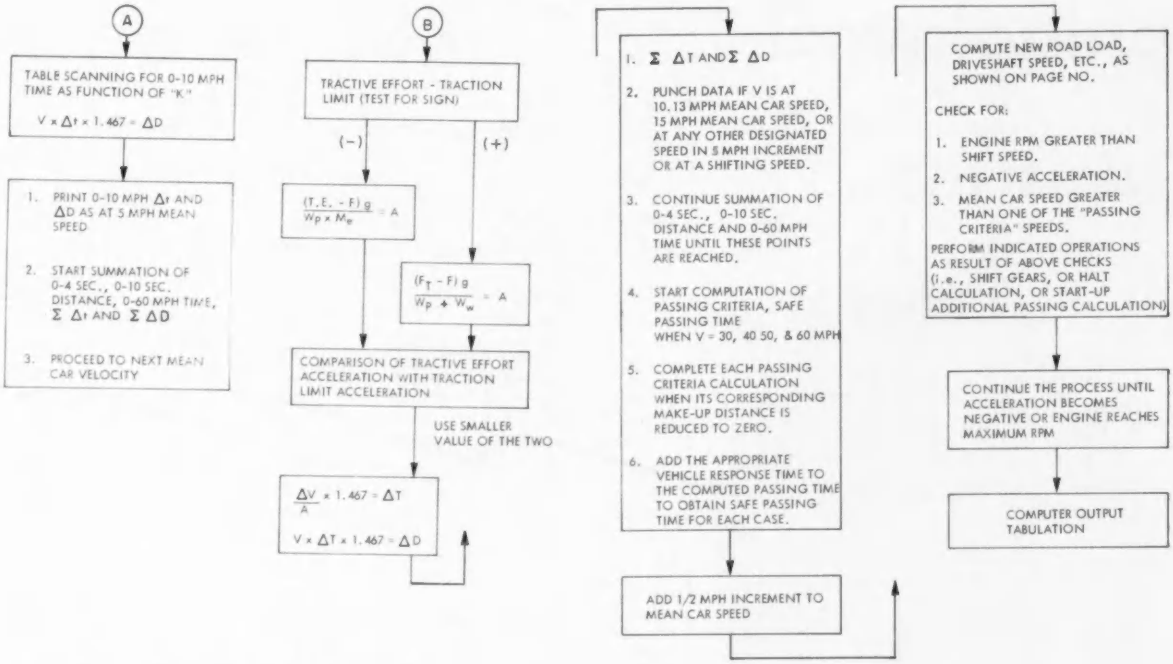
Solution of performance equations by hand calculation

The numerical integration of performance equations can be accomplished with an ordinary desk calculating machine. To reduce the human labor required to process the integration, the magnitude of the dependent variable increment ΔV is increased to 5 mph. Some accuracy is sacrificed to fulfill this objective. The hand calculation process is tedious, time consuming, and continually subject to human error. A computer solution is more effective, saving both time and money.

Computer solution techniques

Since many solutions of the performance equations are required during the normal course of vehicle design, a digital computer was selected to perform the calculations.

A carefully devised set of detailed instructions is prepared to direct the computer during the problem solving process. These instructions are known as a computer program, and they serve a dual function. The program outlines in logical sequence the detailed steps the computer must follow to solve the performance equations. It also prescribes the detailed sequence of operations necessary to transform the equations and related input data into a form acceptable to the computer.



data processing flow chart, IBM 650 digital computer.

The input data previously shown in the form of curves to facilitate illustrations are actually processed by the computer in the form of polynomial equations or tables.

A special set of forms was designed for recording all required input data. These forms are made available to all engineering personnel desiring passenger-car acceleration performance predictions. The coded data from these forms are punched onto cards and fed into the computer.

Fig. 6 is a general schematic flow chart portraying a computer prediction of acceleration performance criteria.

Fig. 7 presents the data processing flow chart expressing computer prediction of acceleration performance for a passenger car equipped with automatic transmission.

Fig. 8 is a sample of the computer output tabulation.

As the calculation proceeds, the computer prints out a progress report of the numerical summation at the end of each 5 mph increment of vehicle speed. The numerical predictions of each performance criterion, vehicle shift speeds, and other pertinent input data are included in the print-out for reference and checking purposes.

Performance prediction system applications

The principal applications of the prediction system fall into two general categories:

1. Determination of powertrain component characteristics to achieve performance objectives for a vehicle design program.

2. Comparison of powertrain components for a specific vehicle.

The first type of investigation requires the prediction of both acceleration performance and fuel economy criteria for a substantial number of hypothetical vehicles. Input data for each powertrain component are arbitrarily selected to cover a wide range of possibilities. The predicted values of time and distance criteria are plotted against values of fuel economy criteria for each hypothetical vehicle. Performance and economy design objectives are then superimposed on these plots. Fig. 9 shows a sample cross-plot for several engine sizes in combination with a series of axle ratios. From this cross-plot it is evident that economy can be optimized for a given performance objective, or vice versa. Variations of the cross-plotting technique can be applied to appraise other component characteristics.

The second type of investigation is employed to study the comparative performance merits of two or more unlike samples of the same component, such as several engines, torque converters, axle ratios. When component characteristics are accurately represented, calculated comparisons are more reliable than test comparisons. In a computer solution all variables associated with test measurements and their reproductibility are eliminated.

Prediction system accuracy and cost data

The accuracy of a computer solution is dependent on two principal factors:

1. The validity of the equations expressing the

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GR 1	GR 2	GR 3	GR 4	SFT 1	SFT 2				
4.000	2.400	01.470	1.000		4200.000			1998.000	2829
SFT 3	**P WT**	**D WT**	**AXL R**	**AXL E**	**C FRC**				
4200.000	4775.000	2297.000	2.910	.965	.950			90000.000	2829
CG HT	**WH BS**	**R R**	**T RPM**	**T MAS**	**T PRS**				
20.600	113.000	01.093	768.000	54.000	23.000		110.000	110.000	2829

VEL	E RPM	RD LD	T EFF	DS SP	DS TQ	ACCEL	T SEC	D FT	CALC	GEAR
5.000	1799.558	83.460	3455.484	240.000	1344.958		1.086	7.964	2829	1
10.130	1947.836	84.042	2953.723	436.992	1149.661	16.763	1.108	8.289	2829	1
15.000	2153.912	87.500	2616.378	624.000	1018.358	14.772	1.579	17.145	2829	1
20.000	2419.163	93.600	2406.303	816.000	936.591	13.510	[illegible]	30.775	[illegible]	[illegible]
25.000	2716.490	101.700	2239.846	1008.000	871.802	12.490		[illegible]		
30.000	3088.019	109.800	2150.233	1200.000	[illegible]	[illegible]			[illegible]	[illegible]
35.000	3503.415	119.960	[illegible]	1392.000			11.600	[illegible]	2829	2
40.000	[illegible]	[illegible]		[illegible]			12.785	859.868	2829	3
42.500					354.171	3.839	14.614	1068.506	2829	3
[illegible]			877.141	[illegible]	341.404	3.392	16.655	1316.360	2829	3
	3547.262	[illegible]	843.659	3385.196	328.373	2.940	18.994	1617.612	2829	3
95.000	3723.542	428.350	813.988	3564.285	316.824	2.487	21.726	1989.645	2829	3
100.000	3897.892	468.900	786.523	3742.589	306.134	2.049	25.000	2459.407	2829	3
105.000	4070.134	510.950	760.178	3920.138	295.880	1.608	29.066	3072.784	2829	3
110.000	4238.431	553.000	722.519	4096.967	281.222	1.093	34.647	3956.070	2829	3
115.000	4402.094	553.000	674.020	4273.116	262.345	.781	42.630	5277.909	2829	3
118.000	4497.356	553.000	639.327	4378.500	248.842	.557	49.466	6449.316	2829	3

			TIME						
4 SEC	10SEC	0-60	**30 MPH**	40MPH	50MPH	**60 MPH**			
109.745	570.359	08.544	5.557	6.819	[illegible]	9.570	1800.000		2829

SAMPLE

Fig. 8 — Computer output tabulation.

Computer predicts car acceleration

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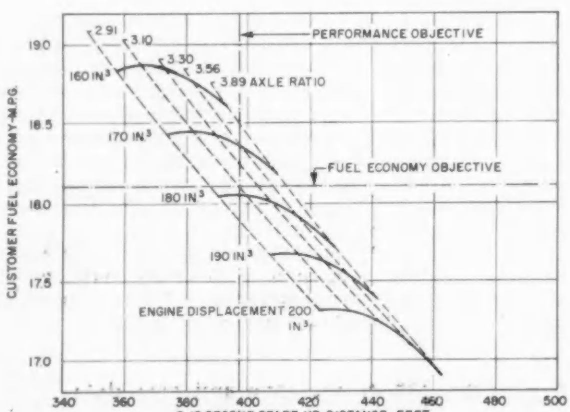


Fig. 9 — Powertrain optimum selection — performance versus fuel economy.

performance criteria.

2. The accuracy of input data employed to solve the performance equations.

Prediction accuracy is defined as per cent deviation from the true mean of a subsequent production vehicle. For vehicles incorporating production powertrain components with known characteristics, the prediction accuracy is ± 5%. For vehicles incorporating future components with carefully estimated characteristics, the prediction accuracy is ± 7%. Mean measured or estimated values of input data are used for all performance criteria predictions.

The accuracy associated with comparison of components will be as good as that related to the input data expressing component characteristics. For examples such as axle ratio comparisons, the comparative error is for all practical purposes nonexistent.

Additional refinement in expression of some of the basic terms of the performance equations is contemplated to provide future accuracy improvement.

The utilization of the prediction system has been steadily increasing since its introduction, as indicated in Fig. 10. During the calendar years 1957, 1958, and 1959, over 4000 separate vehicle appraisals were processed.

The cost and solution-time requirements for com-

puter prediction of all acceleration performance criteria for a single vehicle are very reasonable, as indicated in Table 1. The corresponding average cost and time estimates for slightly less accurate hand-calculated predictions are also listed.

Prediction system cost data

The cost and time data shown in Table 1 for computer calculations are based on the use of an IBM 650 computer. These estimates are based on complete utilization of computer time on many different jobs. However, under most operating conditions conceivable, these costs would be no greater than double the dollar values indicated.

Future outlook

Much remains to be done in perfecting procedures for expressing complex problems by equation systems and in adapting these for solution by computers. The interrelationship of variables expressing powertrain component characteristics require further investigation and study so that more precise methods of representation may be developed. Progress in this direction will be evolutionary in nature and will result in the development of more powerful enginering tools.

To Order Paper No. 196B . . .
from which material for this article was drawn, see p. 6.

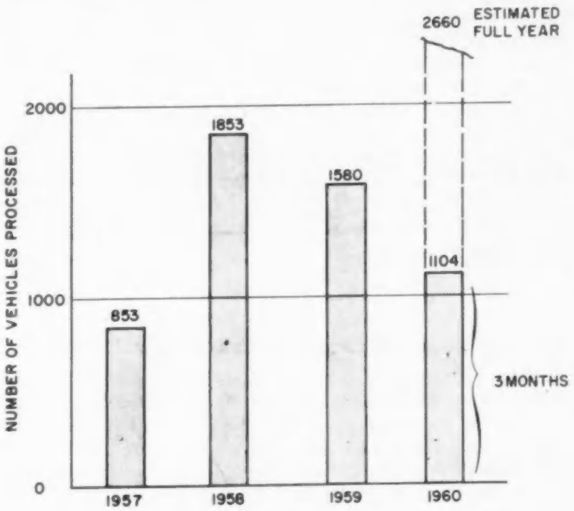


Fig. 10 — Prediction system utilization.

Table 1 — Prediction System Cost Data

	Hand Calculations		Computer Calculations	
	Time, min	Cost, $	Time, min	Cost, $
Automatic Transmission	240	30.00	7	4.00
Manual Shift Transmission	180	22.50	3	2.00

Developing car tires

for 500-Mph speeds

Abridgment of an
SAE Texas Gulf Coast Section Paper

Based on paper by

E. W. McMannis
Goodyear Tire & Rubber Co.

BEFORE undertaking to develop tires to carry a car at 500 mph there are three things you must have:

- Materials with strength adequate to withstand the high centrifugal forces.
- A proved design, which can be applied.

continued on next page

Developing car tires for 500-mph speeds

. . . continued

• Facilities for evaluating the tires before they go on the vehicle.

When we were approached to develop the tires for Mickey Thompson's Challenger 1, which established the American land speed record of 363.67 mph and broke four international records, we said "Yes," but only after we had determined that the three requirements could be met.

We had a material more than twice as strong as cotton in nylon cord with 5.9–9.2 gms/denier. A high strength/weight ratio is very important when you consider that each pound of normal size passenger-car tire exerts a force of over 8000 lb at 420 mph. We had the "flat top" design developed for jet aircraft, which must land at 300 mph. And, finally, we were building a new multistage dynamometer which could simulate both landing and take-off speeds of 320 mph under exact operating conditions. In conjunction with this was a tire-on-tire stage designed to operate to 5500 rpm. On a normal size tire this would be equivalent to 450–500 mph, or adequate to fully test the land speed record (LSR) tires.

Service conditions

The next phase was to engineer the tires, and it began with assembling the known characteristics of car and course, as shown in Table 1. From these data the limits of load, tire height and growth, and tread were defined so that calculations could be made to determine inflation pressure, tire width, and strength necessary to do the job. The minimum size of tire to carry the car at 420 mph was found to be 6.7 in. wide with the 30-in. OD inflated to 100 psi.

Understanding the nature of a distortion or inertia wave in a tire run overload at high speed aids in designing a tire to operate at high speeds. The tire is essentially a spring which is relaxed as it contacts the road, and the tread is weight attached to the end of that spring. Imagine, for example, a weight suspended on the end of a light coil spring. If we raise the weight with the palm of the hand and lower it slowly the weight comes to rest at the original position and there is no work done. But if the weight is raised and dropped suddenly, it will fall below its original position and go into a damped vibration until all of the energy is absorbed into the system. This damped vibration appears on the tire as a distortion wave and all the energy results in heat, which destroys adhesion, melts nylon fabric, and causes porosity in rubber.

Decreasing the vibrations

We can decrease these vibrations in a tire as we do in a spring system. We can increase the spring rate by using higher inflation pressure so that the tire is not deflected as much by the load; we can decrease the weight effect by using a thinner, lighter tread, or we can reduce the amount of deflection by reducing the load on the tire.

Calculating the centrifugal force from a known point (0.5 treaded tire at 100 mph) gave us a tread thickness of 0.025 in. for 400 mph. Since wear is not a factor on the salt flats of Bonneville, the tread was adequate for the LSR tire. A further weight saving was obtained by making the tire tubeless, and the final size was 7.00 × 21.

Testing to evaluate performance

Free spinning the tire through a speed range to 500 mph and measuring the radial growth on the television monitor showed that a radial increase of 0.6 in. with 100 psi at 400 mph was within the 0.75-in. clearance limit designed into the car. The curves obtained that way indicated that the strain on the cord was the sum of the inflation pressure and centrifugal force, since the change in radial growth was proportional to the change in inflation pressure. Temperature data showed the tire operating at the same temperature at 420 mph as a regular automobile tire does at 100 mph.

Performance on the salt flats was better than in the laboratory. Even at speeds over 360 mph the tire temperatures were only 150 F, probably due to the cooling effect of moist salt. The thin tread showed no sign of wear after eight runs. Usually tires are changed after each run because of tread chunking and heat.

Table 1 — Car and Course Characteristics for Land Speed Record of 363.67 MPH.

Car
- 4500-lb curb weight.
- 1000-lb air load at 400 mph.
- 13.5 sq ft of frontal area.
- 30-in. height (tire).
- 0.75-in. tire clearance.
- 4490 rpm, 30-in. wheel at 400 mph.
- 2400 hp.
  - 4 engines; dual tandem, counterrotating.

Course
- Smooth salt.
- Cooled by moisture.
- Nonabrasive.
- Variable traction coefficient.

To order Paper No. S249 . . .
from which material for this article was drawn, see p. 6.

How to get

Positive Gas Sealing with Flared Fittings

Carrying the hoop stress in the nut is a solution to leaky AN-type fittings for high-pressure gas sealing.

Based on a presentation by

C. M. Richards

Convair (Astronautics) Division, General Dynamics Corp.

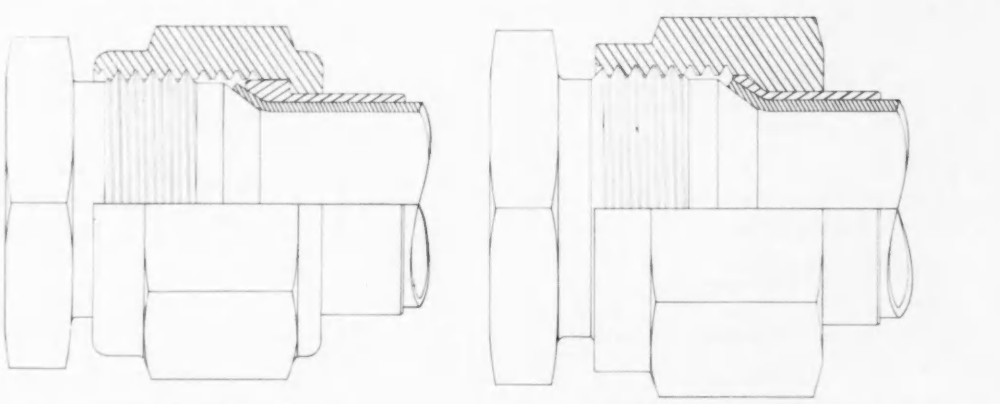
to SAE Committee G-3, Aero Space Flexible Fittings & Flexible Hose Assemblies

PRESENT AN-type fittings don't always do a positive sealing job because the sleeve and nut maximum allowable stresses are reached before yielding occurs at the seal point, research at Convair shows. A possible solution to the problem is an MS 21921 modified sleeve and nut.

Early work at Convair showed that yielding must occur at the seal interface if positive sealing of helium is to be accomplished. These results were confirmed using a fitting material with a 30,000 psi yield (corrosion-resistant steel) and tubing with a 75,000 psi yield.

A comparison of the two types of fittings is shown in Fig. 1 and their performance using the above materials in Fig. 2. In each case the allowable torque on the MS 21921 nut exceeds that required for positive sealing, while the standard AN fitting at best only partially meets the torques required for sealing in three cases. Further, the torque instructions in AND 10064 fall far short of that necessary to produce yielding at the seal point and the resultant positive seal of helium with these typical materials.

Besides meeting the torque requirements for seal-



AN Standard Flared Fitting

Modified Flared Fitting (MS 21921)

Fig. 1 — COMPARISON OF AN AND MS TYPE FLARED FITTINGS shows that the MS type is designed to carry the hoop loads in the nut rather than the sleeve. This design difference allows positive sealing torques.

Positive Gas Sealing with Flared Fittings

. . . continued

ing, the modified configuration would have the following advantages:

1. The weight of the assembly would not be increased for this extra performance.

2. Interchangeability and compatibility with existing installations is maintained.

3. Improved vibration performance would result from the better support provided at the root of the tube flare.

4. Bursting strengths are increased about 20%.

Analysis of AN-type fittings

The actual forces on fittings were determined by mounting simulated fittings in a tension testing machine and torquing the nuts. This gave a direct correlation between torque and tension, and eliminated the undetermined variables. These tension forces represent the net force available to draw the three elements of the fitting together. This force is then resolved into a force acting normal to the sealing surface. It is this normal force that must develop the required 30,000 psi at the seal if yield is to occur and a positive seal result.

This normal force may be broken down into two components, one axial and one radial. The radial component is resisted by and is the result of hoop stresses set up in the sleeve. From this, it may be seen that the limiting factor on the force normal to the seal is the hoop strength of the sleeve. In the smaller size fittings, the sleeve comes close to yielding under AND 10064 specified torques and will yield when a test pressure of 6000 psi is applied. Still the force necessary for yielding at the seal surface may not be reached. It is obvious that the nut is carrying the hoop loads beyond the capacity of the sleeve, even though it is not designed to do this.

The overall torque and stress picture for AN-type fittings is shown in Fig. 3. The torque test results are shown as two limiting curves, which represent the highest and lowest sealing stresses found for a given torque. The points where these two curves intersect the 30,000 psi line bracket the range of torques that *might* be expected to produce a positive

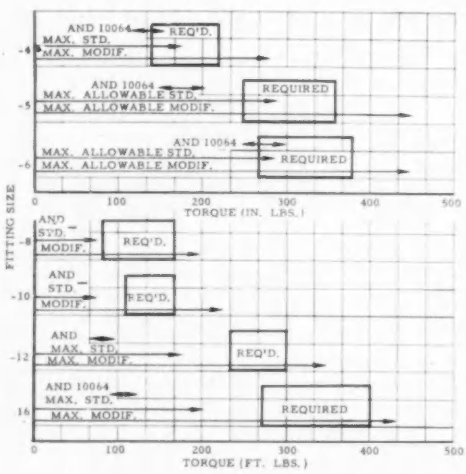


Fig. 2 — A PERFORMANCE COMPARISON of the two types of fittings shows that in only three sizes of AN fittings there is a possibility of positive sealing without excessive torque. Only in the ¼ and ⅜ sizes are the specified torques even in the required range. This accounts for the relative reliability of these size fittings in sealing gases.

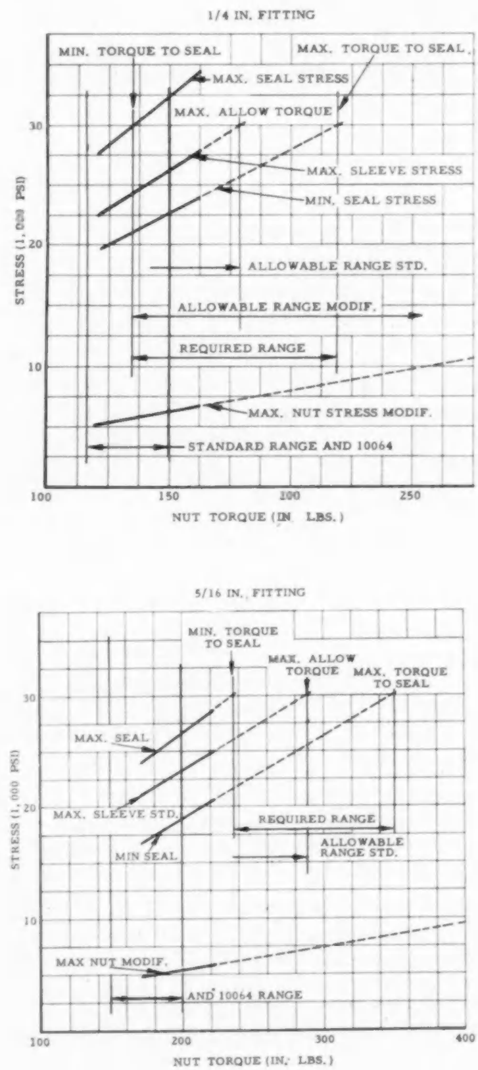
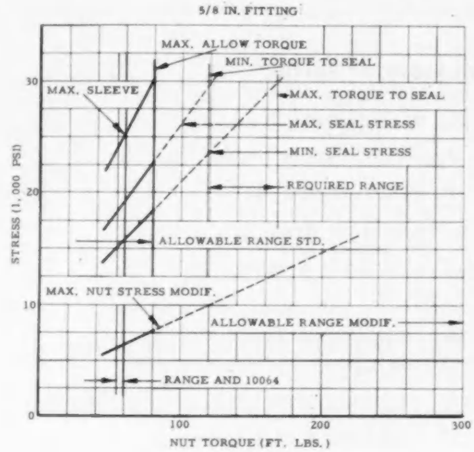
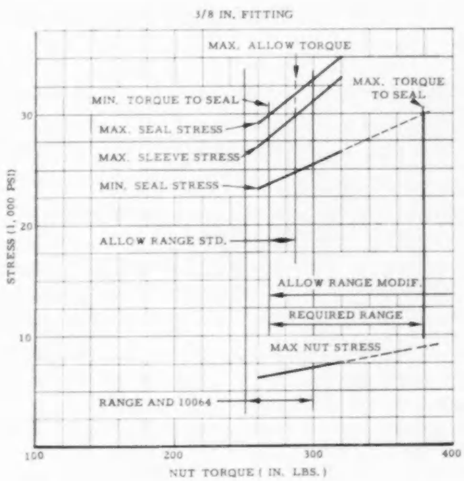


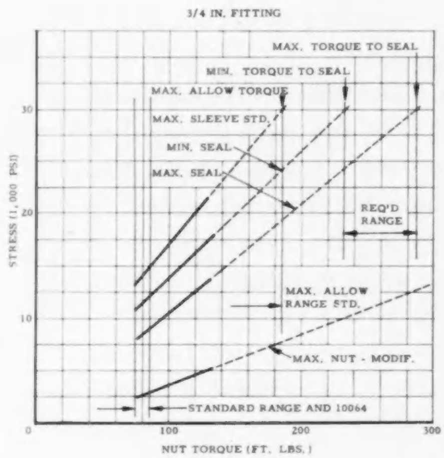
Fig. 3 — STRESS-TORQUE PLOT for the

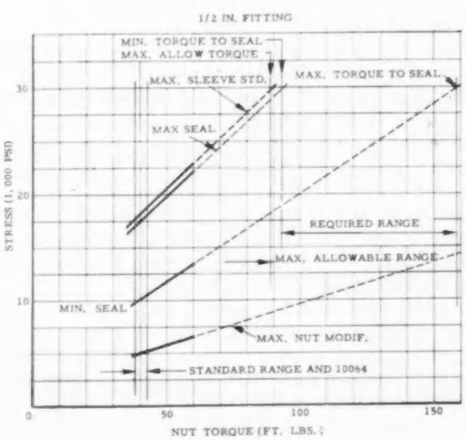
seal. To insure a seal every time, the torque applied should be above this range. Also plotted is the maximum sleeve stress for various torques. When a sleeve stress of 30,000 psi is reached, the corresponding torque is the maximum allowable torque. Otherwise, the sleeve may yield, jamming the nut threads or transferring the hoop load to the nut.

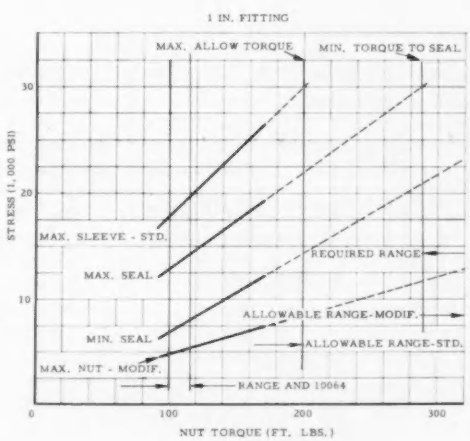
On the same graphs, the nut stress of the modified MS 21921 fitting is plotted. In this type fitting, the heavy nut is designed to take the hoop stress and the sleeve has been reduced to a vestigial structural element. For each size of fitting, the maximum allowable torque is far above the range required for sealing.











sleeve, sealing surface, and modified flared fittings for sizes from ¼ to 1 in.

Glossary of terms

F_{net} = net thrust, lb

F_{jt} = nozzle gross thrust, lb

F_P = form thrust, lb

D_f = friction drag, lb

P_∞, P_a = ambient pressure, psia

A_T = total nozzle throat area, sq in.

M_E = supersonic ejector mach number at exit prior to normal shock

M_S = secondary flow throat mach number

M_O = secondary flow entrance mach number

Δ_{aug} = augmentation thrust, lb

W_S = secondary weight flow, lb/sec

W_T = primary weight flow, lb/sec

A_n = local flow annulus area, sq in.

P_n = local flow static pressure, psia

u_n = local flow axial velocity, ft/sec

v_n = local flow normal velocity, ft/sec

ρ_n = local flow density

$\Delta\rho_n$ = incremental density

Δu_n = incremental axial density

Δv_n = incremental normal velocity

n = 1, 2, 3 — referenced to each local annulus

F_n = external force (pressure force, viscous force, etc.) experienced by jet exhaust

P_{T_n} = local flow total pressure, psia

x = axial distance from exhaust plane

τ_x = total stress

f(K) = function of the type of acoustic source and radiation field assumed

ψ = f (A_1, A_2, A_3 and U_1, U_2, U_3)

a_a = ambient speed of sound

ρ_a = ambient density

W_a = jet acoustic power

SPL = rms sound pressure level, db

OSPL = overall rms sound pressure level, db. All db values referenced to 0.0002 dynes/cm^2

Δdb = attenuation (noise reduction)

$W\sqrt{\theta}$ = corrected total weight flow

Momentum cut 20 db

. . . during scale model tests. Expect 9db

Thrust loss no more than

Based on paper by

Emanuel J. Stringas

Research Division, Curtiss-Wright Corp.

MOMENTUM EXCHANGE SILENCERS have cut jet noise up to 20 db during tests conducted by Curtiss-Wright. Scale model test data exhibited peak-to-peak attenuation of 20 db along maximum exhaust noise azimuths at a nozzle pressure ratio of 3.1.

Two of these exhaust nozzles were designed and tested utilizing the flow concentricity technique (evaluating the effect of area splitting on the total sound power emitted by a jet exhaust). The two models were essentially bi-annular multiexhaust plane nozzle configurations. A sketch of the basic model is shown in Fig. 1.

Models were made up of three convergent flow passages — a center convergent nozzle and two co-annular nozzles. The model was designed in such a manner as to permit variation of the outer annular area for various fixed inner annular and center flow areas. The basic configuration with only 22% of the total mass flow passing through the center nozzle achieved an overall attenuation of 3.5 db at a pressure ratio of 2.00, and an overall attenuation of 20 db at a pressure ratio of 3.10. This configuration exhibited a gross thrust equal to that of a conventional convergent nozzle. However, gross thrust augmentation was required to offset the higher friction drag which is inherent in this type nozzle due to increased wetted areas.

These higher friction drags can, however, be reduced by either or both of the following methods: (1) optimization in the design of the concentric passages, and (2) utilization of a simple ejector system. The latter augmentation type was utilized in the second concentric convergent configuration. This final configuration was essentially a fixed area version of the variable first model and was designed to pass 20% of the total mass flow through the center passage. It is shown in Fig. 2 with the ejector at its design position.

Acoustically, this second model exhibited excel-

exchange silencers

from jet noise

reduction on commercial bypass jets, 14 db on 2-spool jets.

with multilobe suppressors.

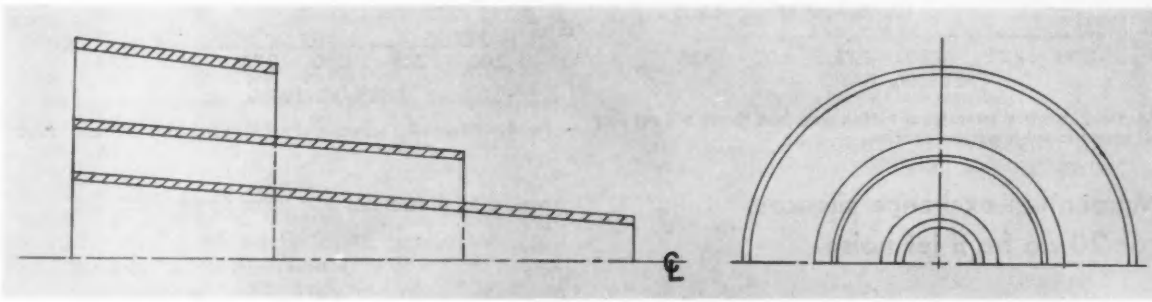


Fig. 1 — Basic suppressor exhaust nozzle.

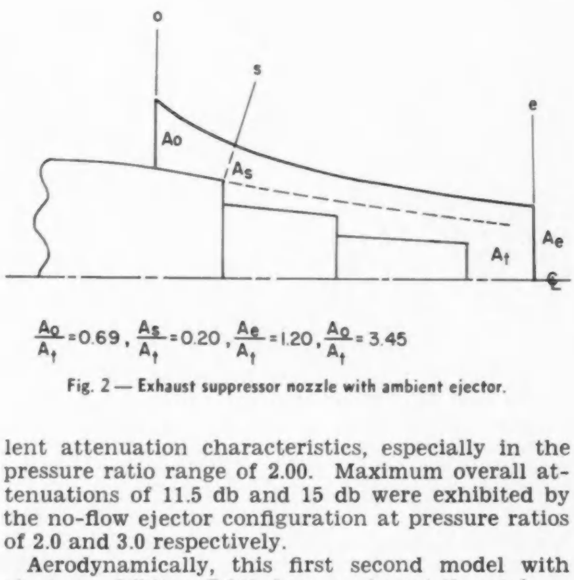


Fig. 2 — Exhaust suppressor nozzle with ambient ejector.

lent attenuation characteristics, especially in the pressure ratio range of 2.00. Maximum overall attenuations of 11.5 db and 15 db were exhibited by the no-flow ejector configuration at pressure ratios of 2.0 and 3.0 respectively.

Aerodynamically, this first second model with ejector, exhibits a 7.0% decrease in net thrust from an equivalent convergent configuration. This value is comparable to those obtained by current multilobe nozzles with and without ejectors at pressure ratios of 2.00.

Theory

The nature of noise caused by mixing of the jet into the ambient environment suggests certain methods of suppression and control. Obviously, the noise is produced by the action of the jet stream after leaving the nozzle. Experimental data and certain analytical works have shown the noise to be a function of jet velocity, temperature, turbulence, shear boundaries and other parameters which all tend to describe the rather violent decay of the exhaust gas jet. Therefore, alteration of the initial jet stream shape, with a resulting change in the downstream mixing process would appear to be the most likely method of tackling the external aerodynamic noise portion of the problem.

Measurements performed on standard conical type nozzles have shown the origin of the high frequency portion of the exhaust noise spectrum to be located near the nozzle exit, the middle frequencies somewhat further downstream, and the predominant low frequency noise origin to be up to ten nozzle diameters distant from the nozzle exit. This in itself would indicate the noise to be, in a large part, due to the turbulence resulting from the jet stream mixing and decay process, the magnitude of which increases as the distance from the nozzle becomes greater.

At distances very close to the nozzle exit, up to one nozzle diameter distant, the peak noise frequencies

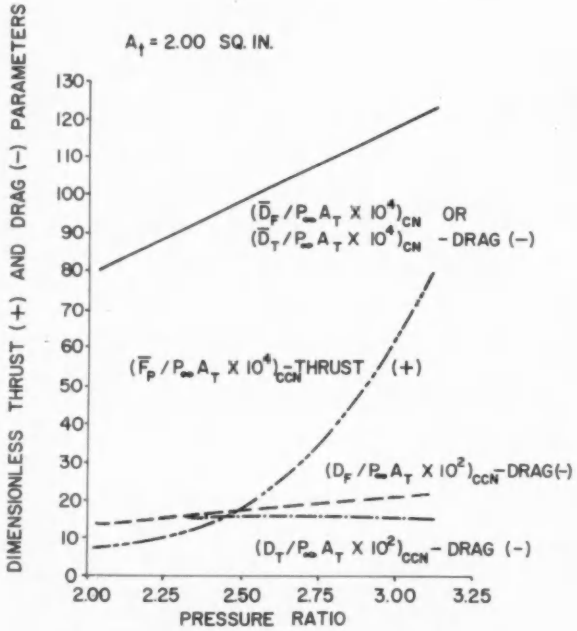


Fig. 3 — Theoretical estimates of friction drag, form thrust, and net drag of concentric and convergent nozzles.

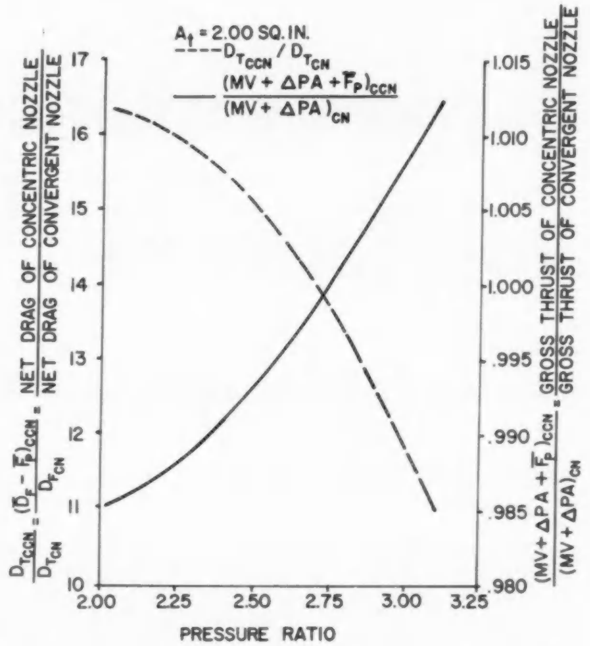


Fig. 4 — Theoretical estimates of net drag and jet gross thrust ratios.

Momentum exchange silencers cut 20 db from jet noise

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are in the order of 100,000–150,000 cps. It can be reasonably assumed that this noise is generated by the very fine eddies formed by the streamline flow jet stream core, traveling at or near sonic speed. If it were possible to maintain this exhaust stream velocity and prevent jet velocity decay, no problem would exist, since the aerodynamic noise would thus be confined to frequencies mostly out of the range of hearing and would be attenuated in air over extremely short distances. Conversely, a tremendous amount of air or other gases can be moved at extremely low velocities with practically no generated sound.

Neither of these extreme opposites are practical in reality. Therefore, actual methods of altering the exhaust gas flow pattern must be compromised. To maintain thrust for a given engine, it would seem that methods other than pure velocity control must be developed. This leaves as variables to be attacked: the shear gradient between the exhaust jet and ambient, the spreading characteristics of the jet, mass flow split to control noise frequency shift, and any other variables which may affect these interrelated phenomena.

Thrust characteristics of the two basic models (approximately 20% of total mass flow through the center jet) were computed assuming that the net thrust was made up of the friction drag, form thrust (due to extended conical annuli surfaces) and the nozzle gross thrust. This net thrust can be expressed in dimensionless form as follows:

$$\frac{F_{NET}}{P_\infty A_T} = \underbrace{\overbrace{\frac{F_{JT}}{P_\infty A_T} + \frac{F_P}{P_\infty A_T}}^{\text{jet gross thrust}}}_{} - \frac{D_f}{P_\infty A_T}$$

$$\underbrace{\frac{F_{JT}}{P_\infty A_T}}_{\text{nozzle gross thrust}} \qquad \underbrace{\frac{F_P}{P_\infty A_T} - \frac{D_f}{P_\infty A_T}}_{\text{net drag}}$$

Dimensionless friction drag, form thrust, and net drag are shown in Fig. 3 together with the net drag of the equivalent convergent nozzle. In Fig. 4 the net drag ratio (concentric to convergent) as well as the jet gross thrust ratio as a function of pressure ratio is presented for informative purposes. Examination of Fig. 4 indicates that from the jet gross thrust point of view, the concentric configuration will exhibit approximately a 1.5% jet gross thrust loss at 2.03 pressure ratio, and approximately 1.2% jet gross thrust increase at 3.10 pressure ratio. Therefore, the main disadvantage of any concentric configuration is its inherently high friction drag.

The net jet thrust curves presented in Fig. 5 indicate that the thrust losses in the range of 6.0 — 9.2% will be exhibited by both the approximate 20% mass flow center jet concentric configurations in the pressure range of 2.0 to 3.0. However, these losses were reduced when a small ejector was designed and installed with the concentric configuration. The ejector was designed with an exit area equal to 1.20 of the total concentric flow area. The pertinent aerodynamic characteristics of this ejector are shown in Fig. 6. The Mach number (M) in Fig. 6 is the supersonic value before the flow undergoes a normal shock at the ejector exit. Maximum ejector weight flow obtainable was in the order of 10% and

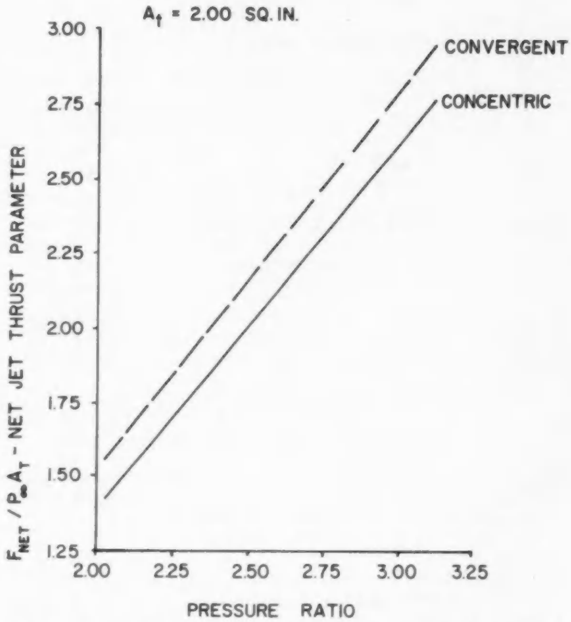

Fig. 5 — Theoretical estimate of net jet thrust parameter for concentric and convergent nozzles.

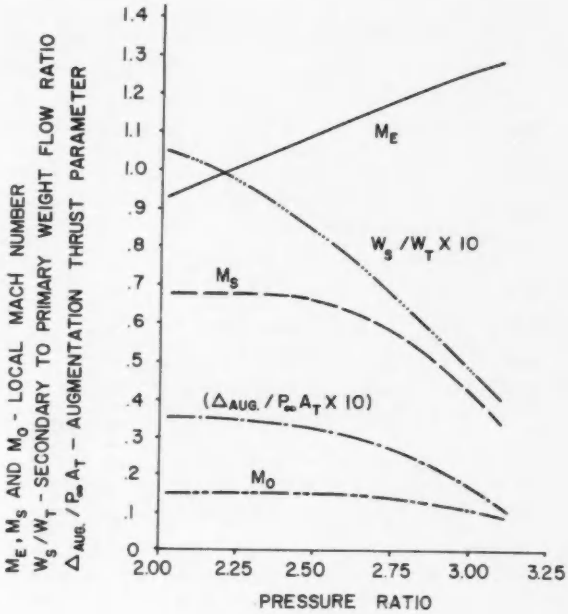

Fig. 6 — Ejector characteristics.

decreased with increasing pressure ratio.

Since the degree of induced air decreases with pressure ratio, the augmentation parameter $\Delta_{aug.}/P_\infty A_T$ must of necessity decrease also. The degree of improvement is readily apparent from Fig. 7, especially in the lower pressure range where the net jet thrust loss was decreased to 7.0% compared to the 9.2% value of the naked configuration. This is a decrease of approximately 25% from the non-ejector configuration. This comparatively large improvement was obtained with a relatively small ejector and a larger amount of augmentation could have been obtained with a larger ejector. However, this would not have been without penalty, since the structure weight and shroud drag would have been increased.

Acoustic characteristics of both concentric configurations are dependent on the mass term of the momentum transfer equation. Since the exit velocity was kept constant for each flow passage, the decrease or increase in sound pressure energy will be a function essentially of the area splits. This in turn will be reflected in the magnitude of the "momentum flux" terms. A qualitative approach to the

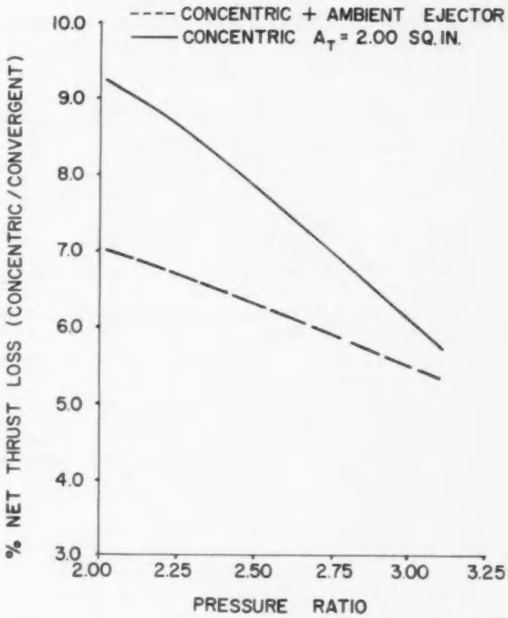

Fig. 7 — Estimates of per cent decrease in thrust with and without augmentation.

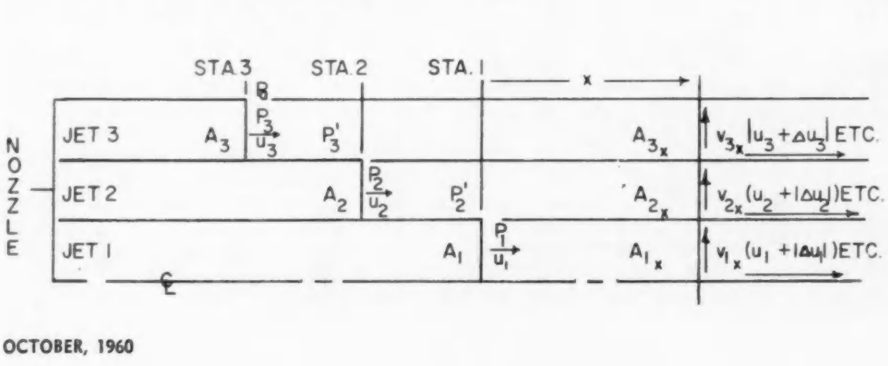

Fig. 8 — Concentric extended annuli exhaust nozzle.

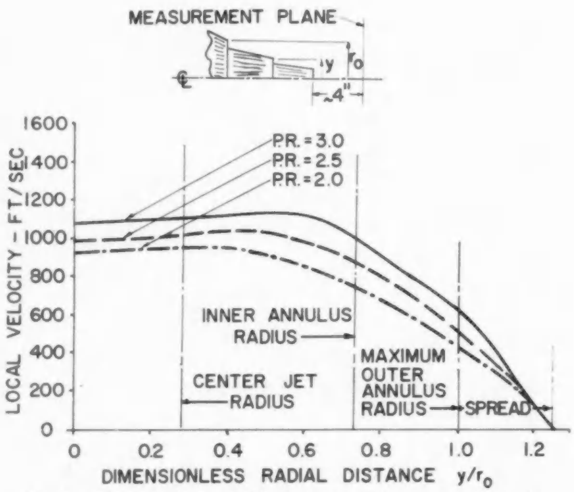

Fig. 9 — Typical velocity profiles for concentric convergent nozzle.

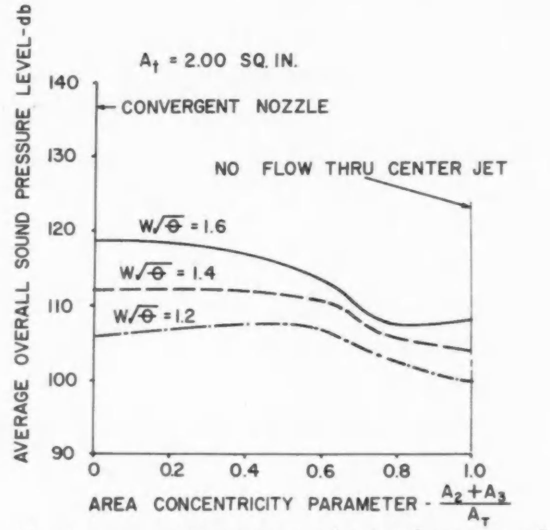

Fig. 10 — Area concentricity parameter as function of average overall sound pressure level at various corrected weight flows for basic concentric and convergent nozzle configurations tested.

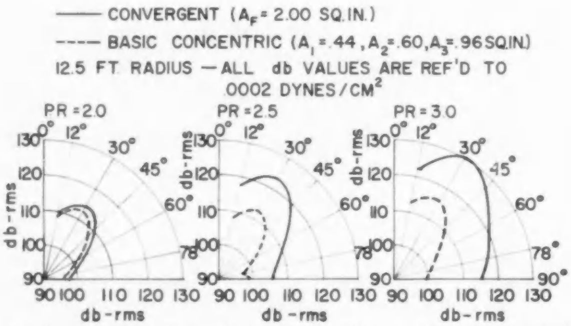

Fig. 11 — Noise polars of the basic concentric nozzle and a standard convergent nozzle, OSPL values.

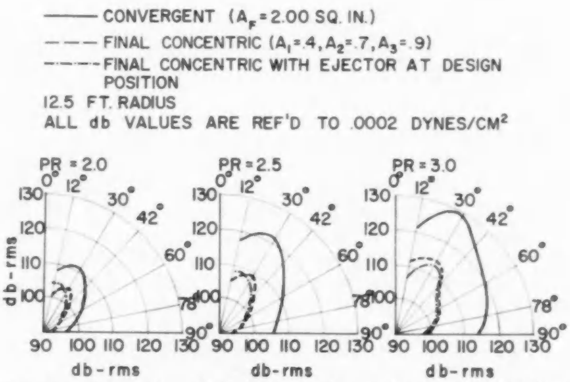

Fig. 12 — Noise polars of final concentric nozzle — with and without ejector — and a standard convergent nozzle, OSPL values.

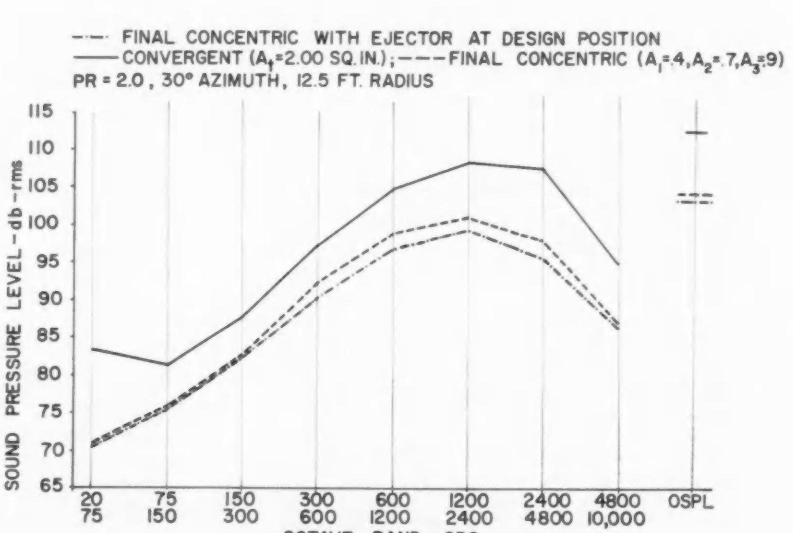

Fig. 13 — Typical noise spectrums of final concentric nozzle — with and without ejector — and standard convergent nozzle.

Momentum exchange silencers cut 20 db from jet noise

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noise generation of a concentric extended annuli exhaust nozzle is presented below. . . .

At some station x (Fig. 8), before the jet decays completely, the total stress (which is in turn proportional to the acoustic power generated) can be broken down into a convective part (the momentum that must be transported through a unit surface area)

$$A_{3_x}\,[\rho_3 + |\Delta\rho_3|]\,[u_3 + |\Delta u_3|]\cdot v_3 + \cdots A_{n_x}[\rho_n + |\Delta\rho_n|]\,[u_n + |\Delta u_n|]\,v_n$$

and the so-called external force (which includes the pressure force, viscous force, etc.) that must exist across this same unit area.

$$F_{1_x} + F_{2_x} \cdots + F_{n_x}.$$

Therefore, the total stress (τ_x) of the three flow areas is as follows:

$$\tau_x = \sum_{n=1}^{n=3} A_{n_x}\,[\rho_n + |\Delta\rho_n|]\,[u_n + |\Delta u_n|]\,v_n + F_n.$$

For sonic operating conditions up to a pressure ratio of 3, the spreading characteristics can be considered negligible.

$$A_{3_x} \approx A_3 \quad \cdots A_{n_x} \approx A_n.$$

Since all the passages are at the same energy level,

$$P_{T_0} = P_{T_1} \cdots = P_{T_n},\ \rho_0 = \rho_1 = \cdots \rho_n,\ u_0 = u_1 \cdots u_n,$$

the expression for the total stress at x can be combined to give:

$$\tau_x = \sum_{n=1}^{n=3} A_n v_n\,[\rho_0 u_0] + A_n v_n\,[|\Delta\rho_n|\cdot u_0 + |\Delta u_n|\cdot\rho_0 + |\Delta u_n|\cdot|\Delta\rho_n|] + F_n.$$

The incremental change in the density and velocity is essentially a function of nozzle underexpansion. The values of these terms may be found by various methods of flow linearization or by the method of characteristics. Therefore, the bracketed expression containing the first and second order terms in the above equation is a function of the adjacent static pressure ratio,

$$\frac{P_3}{P_a},\ \frac{P_2}{P_3{}^1},\ \text{and}\ \frac{P_1}{P_2{}^1}$$

Since the static pressure ratio $P_1/P_2{}^1$ is essentially 1.00, $|\Delta u_1|$ and $|\Delta\rho_1|$ will be small relative to those of the adjacent flow area (A_2), and will be negligible to those of the outer annular flow area (A_3). The normal velocity v_1, will also be small since the energy levels of 1 and 2 are of the same order. This fact is verified by examining Fig. 9. The velocity profiles for these three pressure ratios were taken 4 in. downstream of the center passage exit plane. The normal components v_1, v_2, and v_3 can be evaluated to some degree, by using the turbulent boundary layer expressions of Von Karman and Prandtl for mixing.

Maximum value of incremental density and pressure must of necessity occur at the outer annular flow area since this portion of the jet is expanding into no flow ambient conditions ($u_x = 0$). In other words, the expressions

$$[\rho_0 + |\Delta\rho_3|]\,[u_0 + |\Delta u_3|]\cdot v_3 \text{ and } F_3$$

are maximum at this outer annular flow section.

For a first approximation in determining the relative change in the acoustic power generated for a high pressure ratio hot jet exhaust, the total stress expression can be simplified and expressed as follows:

$$W_a = \int_{A_{surface}} \tau\cdot f(K) \approx f(K)\cdot\left[\int_{A_{surface}} \rho_0 u_0\cdot A_3 v_3 + F_3 + \cdots \int_{A_{surface}} \rho_0 u_0\cdot A_n v_n + F_n\right]$$

where f(K) is a function of the type of acoustic source and radiation field assumed (analogous to Lighthill's coefficient).

It was not feasible to attempt to arrive at a numerical value for f(K) since the tests were limited to one specific total flow area. However, this coefficient can be defined if exhaustive aerodynamic and acoustic testing were undertaken, in which individual area flows, A_1, A_2, and A_3 are indiscriminately varied for a number of constant total flow areas (A_T).

The aforementioned expression for acoustic power can be further simplified if the jet exhaust density is assumed to be equal to ambient (essentially cold flow), the normal velocity (v_n) and force (F_n) are functions of each discrete flow passage area and axial velocity, and the type of acoustic source and radiation field is identical to that of Lighthill. Thus, the expression for acoustic power of a cold concentric jet dumping into still air is

$$W_a = \psi\cdot\rho_a a_a{}^{-5}[A_1 u_1{}^8 + A_2 u_2{}^8 + A_3 u_3{}^8]$$

Results

In order to correlate the results obtained from the basic concentric tests, the ratio of the sum of the inner and outer areas ($A_2 + A_3$) to the total flow (A_T) is plotted in Fig. 10 as a function of average overall sound pressure level for various values of corrected weight flow ($W\sqrt{\theta}$). It can be seen that the lowest average overall sound pressure level exists in the area ratio vicinity of 0.80. Further increases in the percentage of annular flow to total flow produce relatively small reductions in sound pressure level. This criteria of minimum sound pressure level was utilized in the final concentric design. Noise polars of both the basic and final concentric configurations are shown in Figs. 11 and 12. The improvement at a pressure ratio of 2.0 is quite apparent.

Fig. 13 is a typical noise spectrum of the final concentric configuration tested at pressure ratio of 2. Examination of Fig. 13 reveals that excellent attenuation characteristics are exhibited in the first, fourth, sixth, seventh, and eighth octave bands.

A cross-plot of OSPL as a function of pressure ratio in the 42 deg and 78 deg azimuth is presented in Fig. 14 for various basic configurations tested; while in Fig. 15, the OSPL for the final concentric-ejector tests is shown. Both Figs. 14 and 15 reveal that the overall sound pressure level of concentric

Momentum exchange silencers cut 20 db from jet noise

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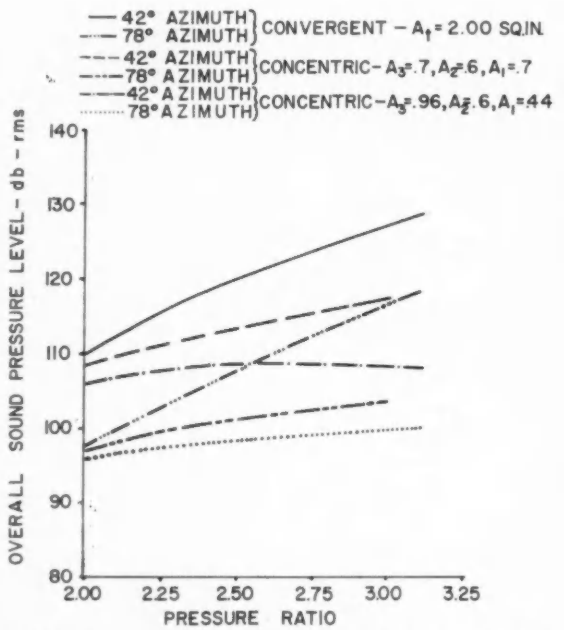


Fig. 14—Comparison of overall sound pressure levels for various basic concentric convergent configurations and a standard convergent nozzle.

configurations are considerably lower than their standard convergent counterparts at all the pressure ratios tested.

Attenuation characteristics of the basic concentric configuration and the final concentric model are shown in Figs. 16 and 17 respectively. Fig. 16 quite vividly illustrates the superiority of the basic concentric configuration, especially in the higher pressure ratio range where a maximum overall attenuation of 20 db at pressure ratio = 3.1 was achieved.

A summary of the overall SPL noise reductions at the maximum azimuth plane (42 deg) as well as at the 78 deg azimuth plane are shown in Table 1 for the basic concentric configuration passing only 22% of the total mass flow through the center nozzle.

In Fig. 17, the final concentric configuration is seen to exhibit better attenuation characteristics at the lower pressure ratios than the basic configuration. The bare final concentric nozzle achieved an overall attenuation of 8.5 db while the no flow ejector configuration indicated an 11.5 db reduction in OSPL at a pressure ratio of two (at 30 deg azimuth). A summary of overall attenuation values attained by the final concentric configuration, with and without the ejector at its design position, is shown in Table 2 for the maximum azimuth plane of 30 deg.

The excellent suppression characteristics of the two concentric configurations are again evidenced when comparisons are made on an average overall sound pressure level basis (average OSPL as used here is simply the arithmetic average of the azimuth OSPL'S). Examination of Fig. 18 reveals that a maximum average overall attenuation of 8.8 db at a pressure ratio of 2 was exhibited by the no-flow ejector configuration, whereas at a pressure ratio of 3.00 the final concentric configuration with the ejector at the design position achieved a maximum

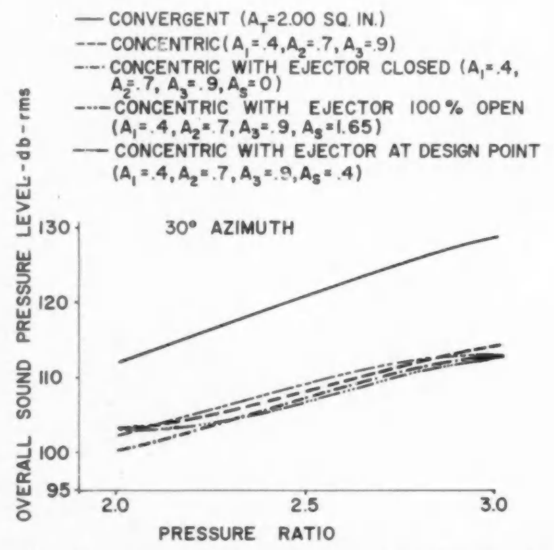


Fig. 15—Comparison of overall sound pressure levels for various final concentric convergent configurations and a standard convergent nozzle.

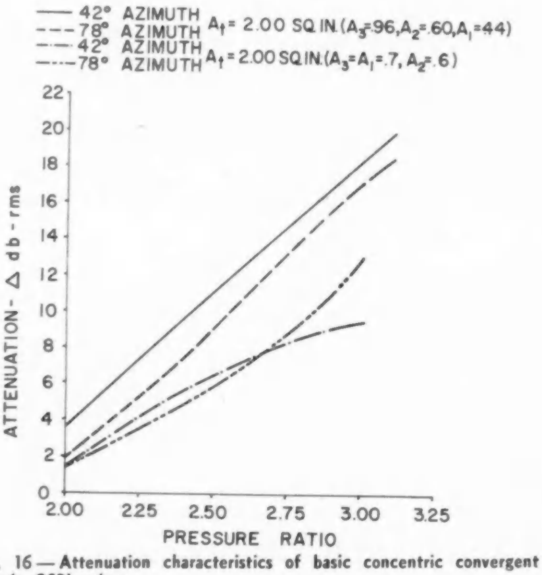


Fig. 16—Attenuation characteristics of basic concentric convergent nozzle, OSPL values.

average overall reduction of 15 db. The best basic configuration is also presented on Fig. 18. It is readily seen that the final concentric configuration improved the average overall attenuation characteristics in the lower pressure ratio range while maintaining relatively high attenuation values at the higher pressure ratios. The average overall sound pressure level reductions for some of the concentric configurations are shown in Table 3.

The directional effects of model jets are approximately the same as their full-scale equivalents. Intensities are about the same at scaled down nozzle diameter distances and the sound power developed closely approximates that predicted by Lighthill's theory. Spectral distribution of model noise is quite different from the full scale, however, with peak model sound levels occurring at much higher frequencies than actual turbojet noise. Small scale noise spectra can be converted to some degree to full scale noise spectral distribution by utilizing "characteristic dimensions" (diameter and frequency wave length) of the model and full scale nozzle. If it is assumed that the suppressed to unsuppressed model noise spectra do not converge at frequencies higher than those measured, full scale estimates can be made directly from the model data.

Thus, in the pressure ratio range of two, where a convergent nozzle has direct application to present day commercial by-pass engines, the concentric nozzle can achieve maximum overall reductions in the order of 9.0 db with no more of a thrust loss than conventional multilobe suppressors. . . . While in the pressure ratio range of 2.6 where some of the large 2-spool commercial turbojets, such as the JT-3 and JT-4, operate with convergent nozzles, maximum overall reductions of 14 db can be expected from a concentric configuration.

To Order Paper No. 162A . . .
from which material for this article was drawn, see p. 6.

Table 1 — Overall SPL Noise Reductions for Basic Configuration Passing 22% Total Mass Flow Through Center Nozzle

Pressure Ratio	42 deg Plane	78 deg Plane
2.0	3.5 db	2.0 db
2.5	11.0	9.0
3.1	20.0	18.5

Table 2 — Overall Attenuation Values Attained by Final Concentric Configuration for Maximum Azimuth Plane of 30 Deg

Pressure Ratio	No Ejector	With Ejector
2.0	8.5 db	9.0 db
2.5	12.5	14.0
3.0	14.5	16.0

Table 3 — Average overall sound pressure level reductions for concentric configurations

	Pressure Ratio		
Configuration	2.0	2.5	3.0
Final Concentric No Ejector ($A_1 = 0.40$, $A_2 = 0.70$, $A_3 = 0.90$ in.^{2})	6.8 db	10.3 db	13.1 db
Basic Concentric No Ejector ($A_1 = 0.44$, $A_2 = 0.60$, $A_3 = 0.96$ in.^{2})	3.7	8.4	14.5
Final Concentric With Ejector at Design Position	6.6	11.0	15.0

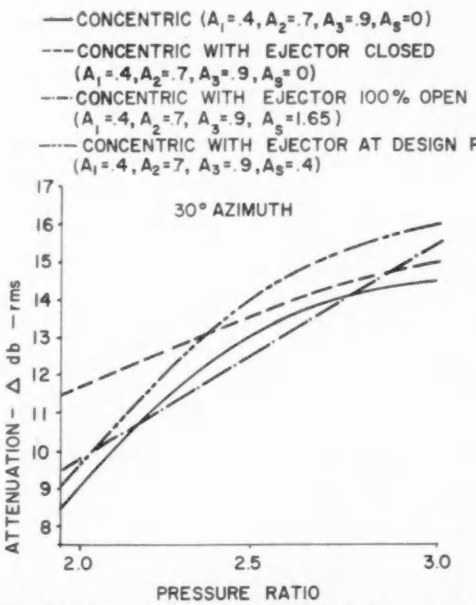


Fig. 17 — Attenuation characteristics of final convergent concentric nozzle, OSPL values.

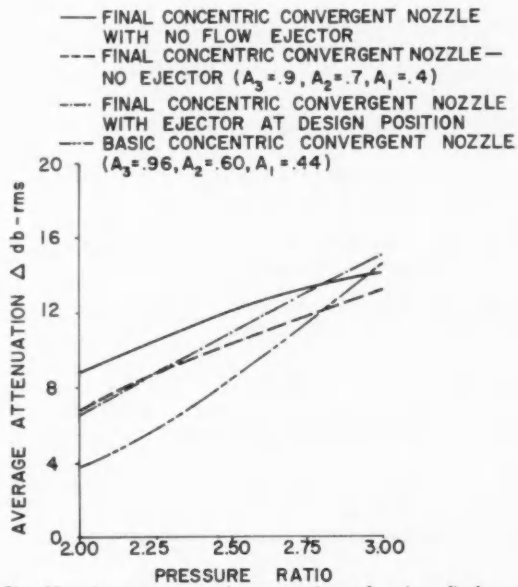


Fig. 18 — Average attenuation comparison of various final concentric convergent configurations and a basic concentric configuration, OSPL values.

designing
with
plastics

Blow-molding and thermoforming plastic shapes

Based on report by

J. H. Versteeg

Union Carbide Plastics Co.
Division of Union Carbide Corp.

THIS IS THE THIRD of a series of six articles, written exclusively for SAE Journal, on "Designing with Plastics for Automotive Applications."

STILL TO COME in the series are articles by:

- A. J. CARTER of Chrysler on Strength and Stiffness Properties of Plastics.
- J. R. FORRESTER of Ford on Plastics Applications Involving Color and Texture.
- P. WEISS of General Motors on Foamed Plastics and Flexible Materials.

PREVIOUS ARTICLES were by J. H. Crate and J. D. Young of du Pont (August), and R. C. Oglesby of Rohm and Haas (September).

ALL SIX ARTICLES will be available early in 1961 as SP-184 at $1.50 to SAE members; at $3.00 to nonmembers. To place your order now, see p. 6.

THE usual fabricating techniques for plastics are injection molding, blow molding, and thermoforming.

Blow molding and thermoforming are both low pressure processes, that is less than 100 psi. Consequently molds can be made from cast aluminum, Kirksite, or thermosetting plastics, such as cast epoxies. Molds cost from 1/5 to 1/10 as much as comparable ones for injection molding.

Blow molding is generally used to form hollow parts (Figs. 1, 2, and 3). However, it is not uncommon for injection-molded and thermoformed shapes to be heat-sealed or cemented together to form hollow parts. Conversely, blow molding can be used in cases which might normally be considered the natural province of injection molding or thermoforming. In this technique, a single shape is blow molded and then cut apart to make two open-faced components. For example, two glove compartments could be blow molded as a single hollow shape, and then cut apart. The availability of large blow molding machines will lead to their predominant use for hollow shapes in the future.

Blow molding had its beginnings in the container field, and is widely used for the production of such items as low density polyethylene squeeze bottles and high density polyethylene detergent bottles. Although the production of containers is still the major use of blow molding, it has found increasing application in other areas, including the production of automotive components.

In this process, a tube of molten plastic is extruded into the space between two separated mold halves. The mold halves then close on the extruded tube, called the parison, so that the top and bottom of the parison are pinched off, except for the hole through which air is injected. This hole is usually

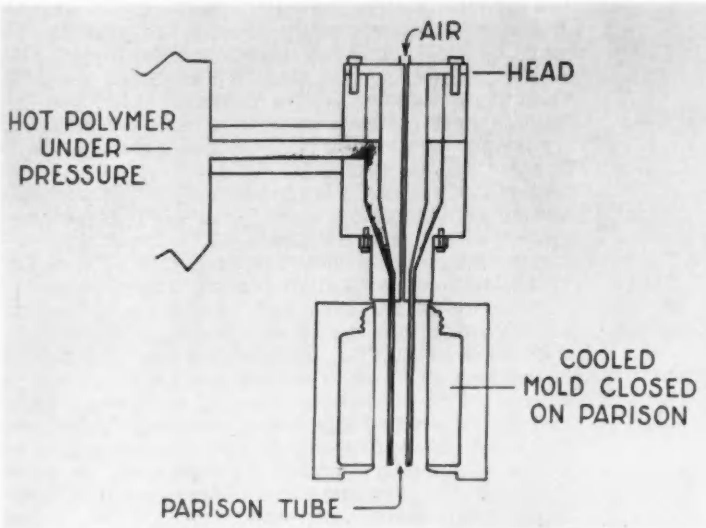


Fig. 1 — BASIC BLOW MOLDING PROCESS. Tube of heated, air-formable material is extruded from cross-head die as indicated.

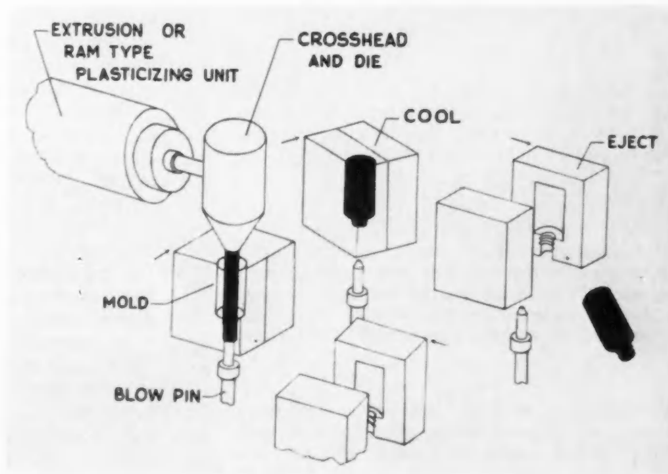


Fig. 2 — INTERMITTENT EXTRUSION BLOW MOLDING. Material is extruded in discontinuous fashion by action of ram. Open mold is positioned before parison is extruded.

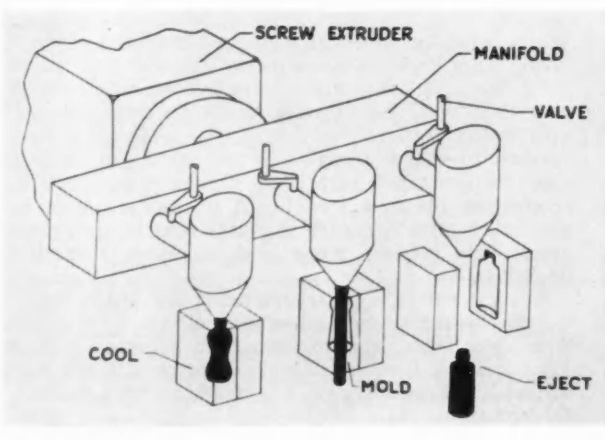


Fig. 3 — CONTINUOUS EXTRUSION BLOW MOLDING. Material is extruded without interruption by action of rotating screw. Valving arrangement allows material to emerge from any of several extrusion dies.

Blow-molding and thermoforming plastic shapes

. . . continued

in the die pin or in the mandrel over which the extruded tube is positioned. The pressure of the air, normally under 80 psi, forces the plastic against the walls of the closed mold, where it cools to the solid state.

The major use of hollow plastics in cars today is for air ducts.

Author J. H. Versteeg is associated with the development laboratories of the Union Carbide Plastics Co. at Bound Brook, N. J. There he is group leader in work having to do with high-density plastics applications.

The production techniques described in this article, he points out, are of special current interest because they are being used increasingly for making automobile interior parts.

He says:

"The rapid increase in use of plastics results directly from introduction of new thermoplastic materials. Until recently, the low and medium cost thermoplastics were restricted in their application because of high temperature limitations.

"Development of high density polyethylene, and later of polypropylene, provided economically attractive materials — with an improvement in heat resistance great enough to make them acceptable for a number of interior applications, including some under the hood.

"Plastics with still better heat resistance, such as polyacetals and polycarbonates, are now becoming available, and their prices are expected to be reduced to the medium price range in the near future. It is worth noting that the prices of plastics continue their downward trend.

"New plastics, which will provide further opportunities for design and engineering improvements, are expected in the future. As a result, use of plastics in automotive applications may well double in the next six to eight years. About 20 lb are used in present cars; 60 lb might easily be used in the foreseeable future."

A General Motors high-heat, high-impact-resistant polystyrene ventilator shroud for example, is made by cementing two injection molded parts together. However, the majority of ducts are now made from high density polyethylene either by heat sealing thermoformed sections, or by blow molding.

An American Motors duct was produced originally in five sections: the body, an inlet, and three outlet sections. It is more than 3 ft long. The sections had to be separately formed, and then joined together with staples or rivets. The five units formerly required have now been replaced by a single unit blow-molded of high density polyethylene.

Pinching-off has been mentioned already in connection with blow molding. When the two mold halves are closed, the plastic within the mold halves is pinched off at each end of the mold by closing action. With a properly designed mold the plastic can also be pinched together at various points within the mold halves to form strengthening columns or ribs which greatly increase the rigidity of the part. There are many applications of this pinching technique — sun visors, arm rests, and door panels can all be given added strength if pinched areas are embodied in the design. If the pinched area is made large, its center can be stamped out to allow shafts to pass through the molding, or other parts to project into the opening. Pinching-off can also be used to produce handles, or to split the flow of air or liquids, or to provide an air vent — the design possibilities are almost limitless.

Other techniques are used to form brackets, such as those to support windshield washer bottles, or snap-in fittings. Windshield washer bottles themselves are now being produced from high density polyethylene. Other uses for hollow plastic parts could include gasoline tanks, designed to fit into the backs of rear seats or even in the roof, bellows for pumping or pedal seals, air cleaner housings, carburetor and gasoline tank floats, horn bells, and glove compartments.

In thermoforming, extruded sheet stock is heated above its softening point, and formed against a mold surface by means of a vacuum or slight positive pressure (Figs. 4, 5, and 6). From this formed sheet can be produced a single large component or a number of smaller components, webbed together. When these parts are separated, the trim is not wasted, but can be reused in the extruder.

The refrigeration industry has converted most of its high impact strength polystyrene door-liner production from injection molding to thermoforming. When injection molding was used, the industry was faced with high mold cost and long delivery times for molds. This was not a favorable economic situation, in view of the industry's annual design changes and multiplicity of models. This industry's conversion to thermoforming produced major savings and reduced the lead time formerly required in tooling-up for new models. A similar situation in the automotive industry suggests that it, too, could adopt this process more fully, and enjoy similar benefits.

A high density polyethylene spare wheel cover for the Ford Falcon station wagon, is a representative open faced application. The requirements of light weight, integral color, embossed surface, and dimensional stability were satisfied by this thermoformed item. The wheel cover by no means repre-

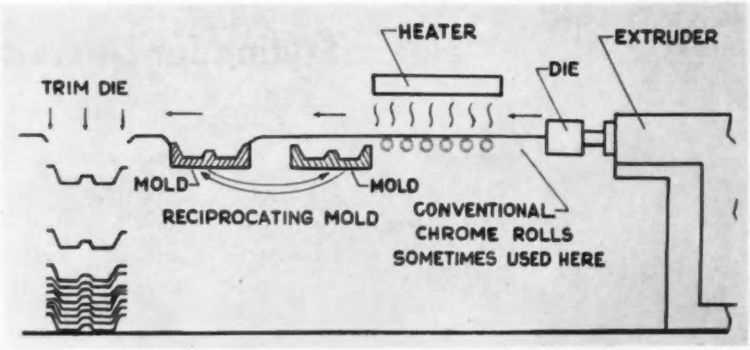
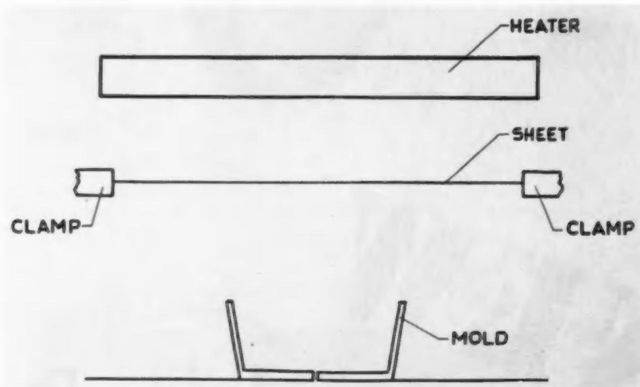


Fig. 4—CONTINUOUS IN-LINE THERMOFORMING. Material is extruded in sheet form, passes under radiant pre-heater immediately before forming.

Fig. 5—VACUUM FORMING PROCESS. Heated sheet is vacuum-drawn to configuration of female forming die.



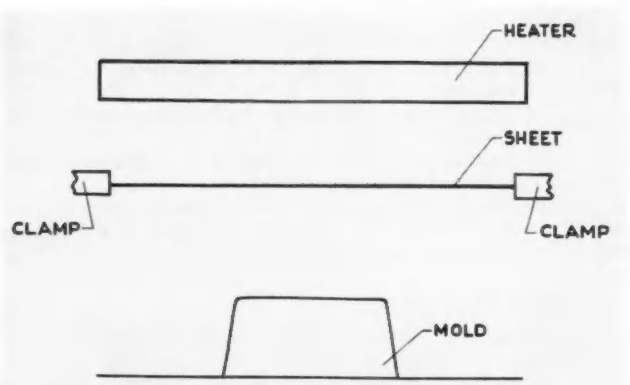


Fig. 6—DRAPE FORMING—A variation of vacuum forming, in which material is drawn down upon male forming die.

sents the limits of thermoforming techniques. This process allows much deeper draws and larger objects to be formed.

Through the use of pressure forming techniques, low cost, plastic impregnated paper or fiber materials can be used for shallow draws. Further possible thermoforming applications include hoods, trunk doors, headliners, door panels, wheel disks, headlight and lamp housings, package shelves, instrument panels, and seat assemblies.

These techniques — blow-molding and thermoforming — are not suggested as panaceas to every design problem. Intelligently and imaginatively used, however, they provide economy, broaden the scope of design possibilities, and yield products that serve the user well.

Styling for Deere's

Fig. 1 — **Styling for American models** of agricultural tractor line.

NEW John Deere Tractors

Excerpts from paper by

Merlin Hansen

John Deere Tractor Research and Engineering Center

JOHN DEERE'S NEW line of tractors comprises four model series and marks discontinuance of three features which had been characteristic of Deere models since the early '20s. Discontinued are: the 2-cyl engine; the Otto-cycle distillate-burning engine; and the practice of mounting the engine horizontally with the crankshaft parallel to the rear-axle.

Horsepower sizes

In the new line, the number of horsepower sizes has been reduced by one. The new line includes FOUR sizes. Table 1 shows the new agricultural and industrial tractor sizes and the chassis options that are available. (The data represent design objectives, since official Nebraska Tractor Test Data are not yet available.)

These new tractors weigh an average of about 25% less per horsepower than did the models they replace.

In these new tractors, the increases in power are expected to be used most effectively in:

- Operating at moderate increases in travel speeds.
- Securing greater usage of hitch-mounted implements.
- Providing increased power for proper operation of larger-capacity PTO implements.
- Making it possible for the operator to maintain his desired travel speed under load (by having more reserve power available).

Styling

Styling of the new agricultural vehicles is illustrated by Figs. 1 and 2.

Special attention was given to the hood, radiator grilles, cowl, instrument panel, seat, fenders, control levers, wheels, and cast-iron balance weights.

Styling on the industrial models follows the same basic concepts as introduced in the Deere industrial line in 1958.

Arrangement of tractor components

On the Model 3010 and 4010 series, the fuel tank is placed at the forward end of the tractor ahead of the radiator, as shown in Fig. 3.

On Models 1010 and 2010, the conventional ar-

New Agricultural Tractors

Fig. 2 — **Styling for European models** of agricultural tractor line.

Table 1 — Agricultural and Industrial Tractor Power Sizes and Chassis Options

Model Series	Horsepower[1] At 1000 rpm of PTO	Horsepower[1] At Maximum Recommended Engine Rpm	Chassis Options Available
1010	30	35	Single row crop tractor Low-center gravity utility tractor Wheel-type industrial tractor Agricultural crawler tractor Industrial crawler tractor
2010	38	45	Row crop utility tractor Row crop tricycle tractor with option of double knuckle, single front wheel, front wheel load equalizer, or adjustable tread front axle Hi-crop tractor Wheel-type industrial tractor Industrial crawler tractor
3010	50	55	Row crop utility tractor Row crop tricycle tractor with option of double kunckle, single front wheel, front wheel load equalizer, or adjustable tread front axle Standard treat (wheatland) tractor Wheel-type industrial tractor
4010	70	80	Row crop tricycle tractor with option of double kunckle, single front wheeel, front wheel load equalizer, or adjustable tread front axle Standard tread (wheatland) tractor Hi-crop tractor Wheel type industrial tractor

[1] The horsepower values shown are secured at the **PTO** drive. All engines may be operated at full load over speed ranges substantially above and below the standard **PTO** speed.

NEW

John Deere Tractors

. . . continued

rangement of the powerplant, transmission, fuel tank, and other components is used.

Powerplant options

Tables 2, 3, and 4 show the major specifications for the two engine lines available.

Transmissions

The 1010 series of wheel tractors has a conven-

Powerplant Options

Table 2 — 4-Cyl Powerplants Manufactured at Dubuque, Iowa

Bore and Stroke	No. of Cylinders	Fuel Used	Usage for Powerplants: Tractor Models	Other
$3\frac{1}{2} \times 3$	4	Gasoline	1010 Series	Implements
$3\frac{5}{8} \times 3\frac{1}{2}$	4	Diesel	1010 Series and Lanz	. . .
$3\frac{5}{8} \times 3\frac{1}{2}$	4	Gasoline	2010 Series	Implements
$3\frac{5}{8} \times 3\frac{1}{2}$	4	LPG	2010 Series	Implements
$3\frac{7}{8} \times 3\frac{1}{2}$	4	Diesel	2010 Series	Implements

Note: All engines operate at crankshaft speeds from 1500 to 2500 rpm under full load conditions.

Table 3 — 6-Cyl Powerplants Manufactured at Dubuque, Iowa

Bore and Stroke	No. of Cylinders	Fuel Used	Usage for Powerplants: Tractor Models	Other
$3\frac{5}{8} \times 3\frac{1}{2}$	6	Gasoline	. . .	Implements
$3\frac{5}{8} \times 3\frac{1}{2}$	6	LPG	. . .	Implements
$3\frac{5}{8} \times 3\frac{1}{2}$	6	Diesel	. . .	Implements
$3\frac{7}{8} \times 3\frac{1}{2}$	6	Diesel	. . .	Implements
$3\frac{7}{8} \times 3\frac{1}{2}$	6	LPG	. . .	Implements
$3\frac{7}{8} \times 3\frac{1}{2}$	6	Gasoline	. . .	Implements

Note: All engines operate at crankshaft speeds from 1500 to 2500 rpm under full load conditions.

Table 4 — Powerplants Manufactured at Waterloo, Iowa

Bore and Stroke	No. of Cylinders	Fuel Used	Usage for Powerplants: Tractor Models	Other
4×4	4	Gasoline	3010 Series	. . .
4×4	4	LPG	3010 Series	. . .
$4\frac{1}{8} \times 4\frac{3}{4}$	4	Diesel	3010 Series	. . .
4×4	6	Gasoline	4010 Series	. . .
4×4	6	LPG	4010 Series	. . .
$4\frac{1}{8} \times 4\frac{3}{4}$	6	Diesel	4010 Series	. . .

Note: All engines operate at crankshaft speeds from 1500 to 2200 rpm under full load conditions.

tional 5-speed selective gear transmission. The 1010 crawler series has a 4-speed selective gear transmission.

The 2010, 3010, and 4010 series have transmissions that provide 8 forward and 3 reverse speeds. This is achieved with a high, low, and reverse range gearset ahead of a 4-speed gearset. All speeds are secured with constant-mesh helical gears.

The agricultural tractors have plate-type synchronizers on the high, low, and reverse ranges; while industrial tractors have collar shifts for these ranges.

Hydraulic system and hydraulic options

Two basic types of hydraulic systems prevail in these new models, because the two larger sizes need greater hydraulic capacity and more hydraulic functions than are necessary on the smaller sizes. Table 5 outlines the important specifications of each.

Table 5 — Hydraulic System Characteristics

Tractor Model Series	Basic Type of Circuit	Type of Pump	Rated Working Pressure, Psi	Capacity[1] Gal. per min.	Rockshaft Lift capacity[2] lb.	Remote Cylinder		
						Size Bore & Stroke in.	Force in Lb.[3]	
							Extending	Retracting
1010	Open center	Conventional Gear	800	8	1800	$3\frac{1}{2} \times 8$	6,900	6,200
2010	Open center	Conventional Gear	1150	11	2600	3×8	7,300	6,300
3010	Closed center	8 piston variable displacement	2000	18	3600	3×8	12,700	10,900
4010	Closed center	8 piston variable displacement	2000	18	4500	3×8	12,700	10,900

[1] Based on the engine operating at standard PTO speed, and the pump working against "rated" pressure using oil at 90 SUS.

[2] This lifting capacity refers to vertical lifting force available at the draft link hitch points at the center of the lifting stroke and 90% efficiency.

[3] The values shown are based on rated pressure and 90% efficiency.

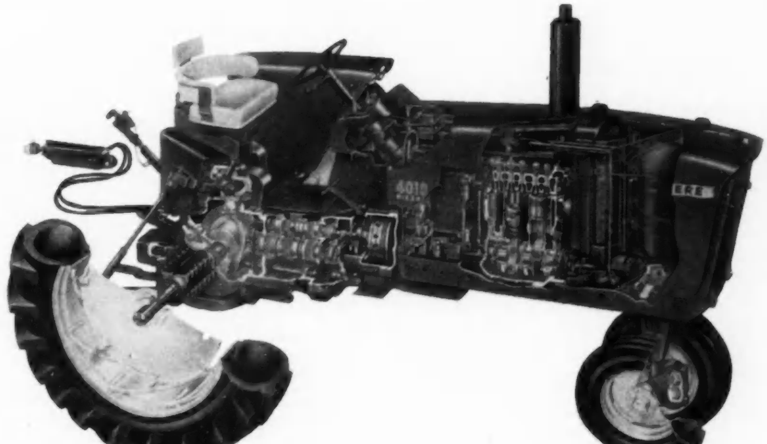


Fig. 3 — **Arrangement of components** in Model 3010 and 4010 series of new Deere tractor line.

On the two smaller tractors, the hydraulic pump provides oil for:

a. Power steering (optional).
b. A single rockshaft (optional).
c. A split rockshaft (optional).
d. Either one or two double-acting remote cylinders (optional).

On the two larger tractors, the hydraulic pump furnishes oil for:

a. Power brakes (standard).
b. Power steering (standard).
c. Single rockshaft (optional).
d. Either one or two double-acting remote cylinders (optional).

The rockshaft system on all series of tractors is primarily used to control the three-point, free link hitch. The valving for the rockshaft system is such that it provides for:

a. Position responsive control. (The position of the rockshaft is a function of the position at which the control lever is placed.)
b. Draft responsive control. (The position of the rockshaft is a function of the position of the rockshaft control lever plus the draft load imposed on the three-point hitch.) This feature is not incorporated in the 1010 series.
c. "Load and Depth Control." (A modification of the draft responsive system except that the position of the rockshaft responds only partially to changes in the magnitude of draft imposed by the hitch.)

The double acting remote cylinders are all "selective controlled" in that the cylinders continue to move as long as the control levers are held in either raising or lowering positions. All remote cylinders have adjustable stops on the piston rods for limiting the piston stroke as desired to control the working depth of the implement. All remote cylinder oil lines have breakaway couplers with check valves.

The closed center circuits employed on the larger tractors have flow regulating valves in rockshaft and remote cylinder circuits for the purpose of limiting the rate of oil flow to these functions to satisfactory working levels.

Steering and brakes

Either manual steering or hydraulic-power steering is available optionally on the Model 1010 and 2010 series. On the larger Model 3010 and 4010 series, only hydraulic-power steering is used.

Dry-disc type manually-operated brakes are used on the two smaller sizes; wet-disc hydraulically-actuated power brakes, on the two larger sizes.

Electrical system capacities

Satisfactory starting at – 20 F is the most severe requirement placed on the electrical system. Each system is matched to the starting requirements for each engine option.

Table 6 details the electrical system capacities for each of the four tractor model series.

Power takeoff options

All tractors are offered without a PTO drive and with an "independent," dual-speed 540–1000 rpm design. The dual-speed PTO drive conforms to SAE standards for each speed.

Improved provisions are made in all of these new tractors for furnishing power to agricultural implements and industrial equipment. They will handle drawn or towed machines; hitch-mounted machines; and integral machines.

To Order Paper No. 225B . . .
from which material for this article was drawn, see p. 6.

Table 6 — Electrical System Capacity

Tractor Model Series	Engine Option	System Voltage	Min. Operating Temp. F	Batteries	
				Number	Amp Hr Capacity
1010	Gasoline	12	– 20	1	56
	Diesel	12	– 20	1	85
2010	Gasoline and LPG	12	0	1	56
			– 20	1	85
	Diesel	12	0	1	85
			– 20	2	85
3010	Gasoline and LPG	12	0	1	70
			– 20	2	70
	Diesel	24	0	2	70
			– 20	4	70
4010	Gasoline and LPG	12	0	1	70
			– 20	2	70
	Diesel	24	0	2	70
			– 20	4	70

Note: All batteries are 12 v.

SAE NEWS

SAE LETTERS FROM READERS

From:
E. K. Dunnett (M '58)
Cincinnati, Ohio
Dear Editor:

Recently I had the opportunity to utilize the services of the SAE Placement Service. After furnishing SAE with the required information, offers of many types from many companies began coming in. I must confess that I had underestimated the far-reaching effects of the SAE.

The position I finally accepted through the SAE Placement Service was exactly to my choosing and was also in the geographical location that I had desired.

Needless to say, my sincerest thanks and appreciation are extended to the SAE Placement Service for a most excellent and thorough job of "job hunting" for its members.

From:
L. H. Nagler (M'44)
American Motors Corp.
14250 Plymouth Road
Detroit 32, Mich.
Dear Editor:

Some time ago I took on the job of collecting a file of SAE Transactions for engineering use at American Motors. This collection was inspired largely by availability of a number of Transactions from the 1910's, 20's, and 30's, representing a private collection of SAE member Joe Sladkey, now deceased.

We now have a complete file of Transactions back through 1944, and, with only three gaps, back through 1933.

I wonder if some of these missing issues might be available from some SAE member, or possibly from some other collector?

The issues of Transactions which we need are as follows:

1943	1923
1940	1922
1939	1921
1932	1920 (Part 2)
1931	1919 (Part 2)
1930	1917 (Part 1)
1926	1916
1925	1915 (Part 1)
1924	and anything prior to 1915

YOU'LL . . .

be interested to know . . .

NONMEMBER REGISTRANTS at SAE National Meetings may now deduct their entire registration cost from their initiation fee should they apply for membership within three months of the meeting. This information now appears on each red "Guest" pocket-name-tag.

Here is a recently revised table of fees — based on daily and complete meeting registration, as approved by EAB:

Length of Meeting	Daily Fee	Full Meeting Fee
5 Days	$3.00	$12.50
4 Days	3.00	10.00
3 Days	3.00	7.50
2 days	3.00	5.00

WALTER E. THILL's Engineering Activity Membership Program Subcommittee has come up with the names of 327 membership prospects.

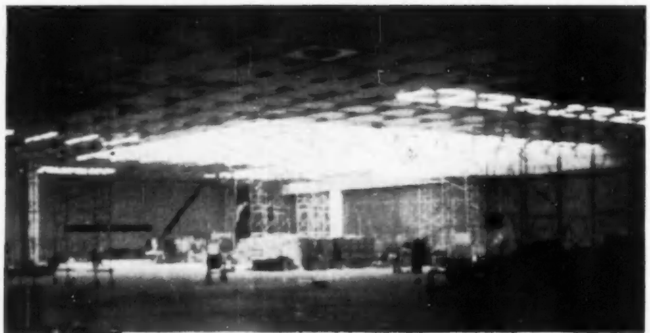
These are early returns . . . and only the beginning, says Thill.

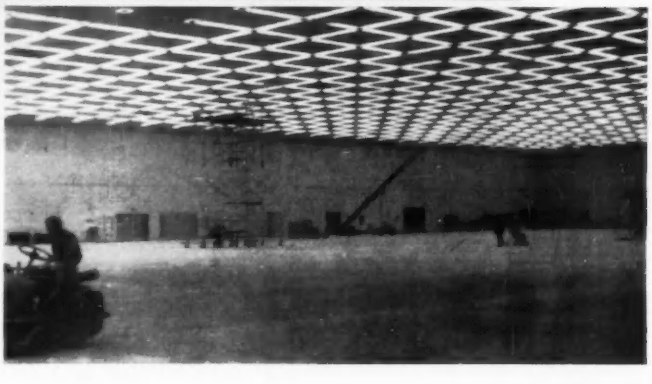
. . . 207 of the names were sent in by C. E. Mines of EAB's Aerospace Powerplant Activity Committee.

ICEAE Cobo Hall Displays Dwarf Previous SAE Shows

FOUR-AND-A-HALF ACRES will be covered by displays at the SAE International Exposition at Cobo Hall in Detroit next January 9–13.

Accompanying pictures emphasize the vast scope of these 1961 SAE exhibits, and dramatize the 10-times-larger-than-ever-before display potentials. The great open spaces shown are only part of the some 200,000 sq ft which will be utilized.





With 90 days before the Exposition opens, only 25% of the display space remains available.

Tied closely to engineering trends to be revealed in 200 technical papers at the SAE International Congress and Exposition of Automotive Engineering, the Exposition displays will feature new and unusual products, materials, and equipment applications. "The products already known to be scheduled for exhibit," according to Display Committee Chairman Ralph H. Isbrandt, "insure great information values for the engineers from all over the world who will be filling the Exposition aisles throughout the Congress."

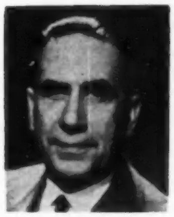
Delegates to SAE's ICEAE Already Named from 7 Nations

SEVEN FOREIGN TECHNICAL SOCIETIES have already named official representatives to SAE's International Congress and Exposition of Automotive Engineering in Detroit next January 9-13. Two aerospace societies and five automobile-oriented groups comprise the seven which made these early delegate designations.

The first society to name its representatives to the ICEAE in response to SAE President Harry E. Chesebrough's invitation was the Canadian Aeronautical Institute. The first of the overseas group to act was Italy's Associazione Tecnica Automobile. Twelve official delegates from these seven countries are scheduled to attend this first SAE meeting to be held in Detroit's new Cobo Hall.

The seven societies have so far named as official delegates the following:

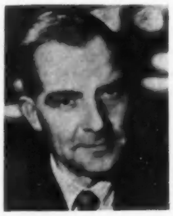
From SPAIN



Ricart

Sociedad de Tecnicos de Automoción — has named as its representative its Honorary President Wilfredo P. Ricart

From ENGLAND



Moult Ballantyne

The Royal Aeronautical Society — has named its President, Dr. E. S. Moult, and its Secretary, A. M. Ballantyne

Heynes Main

Institution of Mechanical Engineers — has named W. M. Heynes, its Automobile Division Chairman, and R. Main, Secretary of the Automobile Division

From ITALY

Capetti

Associazione Tecnica Automobile — has named its vice-president Antonio Capetti

From BELGIUM

Dewandre

Société des Ingénieurs de l'Automobile — has named its President, A. Dewandre

From CANADA

Boyd Luttman

Canadian Aeronautical Institute — has named its President, David Boyd and its Secretary-Treasurer, H. C. Luttman

From JAPAN

Toyoda Yoshiki

Society of Automotive Engineers of Japan — has named its president, E. Toyoda and its Vice-President and General Director, T. Yoshiki

From FRANCE

Société des Ingénieurs de l'Automobile — is in process of naming its official representatives.

It is too early to estimate with any accuracy how many more of the 10 foreign societies who have not yet given definite responses will finally decide to send official representatives.

Among those from which responses have not yet been received are:

Associazione Italiana di Aerotecnica (Italy); Engineering Institute of Canada (Canada); Japan Aeronautic Society (Japan); Association Francaise Ingénieurs et Techniciens de l'Aeronautique (France); Verein Deutscher Ingenieure (Automotive) (Germany); Wissenschaftliche Gesellschaft fur Luftfahrt (Aeronautic) (Germany); Schweizerische Vereinigung für Flugwissenschaften (Switzerland).

Foreign Engineers Eager to Attend

It is too early, also, to guess with any accuracy how many individual engineers from overseas will be in attendance at this 1961 SAE Annual Meeting. . . . Evidence of interest among engineers of South America as well as of overseas countries is coming regularly to SAE Headquarters in New York.

Many technical publications abroad — especially those sponsored by the engineering societies — are giving prominent notice to the upcoming ICEAE. And letters from many overseas engineers to their personal friends in SAE reveal eagerness to be able to attend.

■

Northrop Students Build Model "SAE Air Car"

SAE Student Branchers at NIT (starting left) Albert Takahashi, Ned Engeman, Lamar Fransen, Walter Rugh, and Carmen Pilichi, display their model ground-effects vehicle called by the students the "SAE Air Car."

A GROUP OF SAE ENROLLED STUDENTS at Northrop Institute of Technology — where Morris Kramer is faculty advisor of the SAE Student Branch — have designed, built, and test-flown a model ground-effects vehicle which they have dubbed the "SAE Air Car."

First flights took place in June, after which necessary adjustments were made to correct some faulty flight characteristics . . . and two flights were witnessed at NIT early in July.

Idea man and initiator was Sveinn Thordarson, who says his chief source of information and data was SAE technical publications. Albert Takahashi was responsible for utilization of the data in calculating duct size to overall dimension relationship, as well as engine hp required. The control system was built by Walter Rugh. A Cub 0.09 engine was supplied by Lamar Fransen. Carmen Pilichi fashioned the main venturi and engine mount.

Plans for the project, the students say, call for a full-size, one-man vehicle.

Morris Kramer, faculty advisor of the SAE Student Branch at Northrop Institute of Technology.

'59 Wright Medal Goes to M. G. Childers

M. G. CHILDERS has been named 1959 Wright Brothers Medalist for his paper "Preliminary Design Considerations for the Structure of a Trisonic Transport," presented just one year ago at the Los Angeles Aeronautic Meeting.

An article based on the paper was published in the December 1959 SAE Journal (pp. 66–68) . . . and the full paper appears in 1960 SAE Transactions, pp. 396–407.

Presentation ceremonies are scheduled at the Luncheon on Wednesday, October 12, during SAE's current National Aeronautic Meeting in Los Angeles at the Ambassador Hotel.

As Staff Assistant to the Structures Division Manager at Lockheed, Childers is presently engaged in research and development of new structural concepts. During his 23 years in Lockheed's Structures Division, he has been responsible for the structure on the Constellation series and the C-130 prototype . . . and for a period of years was manager of the Basic Loads and Structural Methods Department within the Division.

The 1959 Wright Brothers Medal Board of Award which selected Childers as medalist was: A. Lombard, Jr., Chairman, E. H. Heinemann, and D. R. Berlin.

M. G. Childers

ICEAE Science Pavilion Plans Nearing Completion

PLANS for the Science Pavilion at SAE's International Congress and Exposition of Automotive Engineering in Detroit's Cobo Hall next January are nearing completion, according to Chairman A. L. Haynes of the Science Pavilion Committee.

A. L. Haynes

The exhibits in the Science Pavilion, the four-man Committee decided at its first meeting last summer, will illustrate "the development of automotive transportation through applied science and engineering."

This broad concept is being implemented by exhibits which will illustrate human factors, energy conversion, transportation mobility, materials development, and human resources and education. In each case, the exhibits will be designed to show applications of science to design and manufacturing. Component hardware, materials, instruments and other similar items will also be displayed.

Centerpiece of the Committee-developed Science Pavilion may consist of large illustrations or models of advanced cars, trucks, aircraft, missiles and satellites . . . mounted, perhaps, on a rotating ring with the names of the five display areas of the Pavilion on its periphery.

"The Science Pavilion," Haynes emphasizes, "is definitely not just another trade show. It will concentrate entirely on depicting the application of science and engineering to transportation."

Serving with Haynes on the Pavilion Committee are P. R. Kyropoulos, Dr. J. E. Goldman, and A. C. Bodeau.

Applications Up Sharply For '59-'60 Section Year

WITH 2288 applications for SAE membership during the Section year ended last May 31, the number seeking to affiliate with SAE turned up sharply following a continuous decline in three preceding years. This latest total equals the 1957-58 showing, though some 400 shy of the 1955–56 top of 2678.

Increases by 20 of the Society's 46 Sections and groups — and addition of a new Section and a new Group — were responsible for this year's healthy upward turn. The gains in these Sections offset by more than 280 the decreases recorded in 18 of the remaining Sections and Groups. (Three Sections and one Group were even with last year.)

In this 1959–60 year, three Sections and one group recorded new highs for the five year period which began with 1955–56. They were: Chicago, Wichita, Ontario, and Salt Lake. Five other Sections equalled their highs for the period: Northwest; Syracuse, Twin City, Virginia, and Washington. Applications outside Section territory this year held exactly to last year's level of 84. But foreign applications hit an all-time high of 105, topping last year's 97. Foreign applications, incidentally, have been steadily upward (in small increments) during the entire period of domestic decline.

Four Sections turned up more than 100 applications in the Section year which closed on May 31, 1960. They were Detroit (474); Chicago (171); Metropolitan (166); and So. California (152). . . . Next highest in this year was Ontario, with 86. The 963 rolled up by this more-than-100 club, represents about 42% of the 1959-60 total.

F&L Seeks Papers From College Sources

AIMING to bring into SAE channels an increasing volume of the important technical information, particularly new research of interest to the automotive industry, developed at colleges and universities, the SAE Fuels & Lubricants Activity Committee has named a special group to explore new possibilities.

J. A. Bolt

Heading this new F&L subcommittee of distinguished professors, is J. A. Bolt, professor of mechanical engineering, University of Michigan.

Serving with Bolt are: E. S. Starkman, professor of mechanical engineering, University of California; M. R. Fenske, director of the petroleum refining laboratory at Pennsylvania State University; A. R. Rogowski, associate professor of mechanical engineering, Massachusetts Institute of Technology; and W. H. Paul, professor of mechanical engineering, Oregon State College.

GM President To Be January Dinner Speaker

JOHN F. GORDON, president of General Motors, has accepted SAE's invitation to be the principal speaker at the 1961 Annual Meeting Dinner, which will be a high spot of SAE International Congress and Exposition of Automotive Engineering in Detroit's new Cobo Hall next January. The dinner will be held on Wednesday, Jan. 11, 1961.

John F. Gordon

The main banquet room in Cobo Hall, where Gordon will talk, will seat 2800 diners, the largest group ever to attend an SAE banquet.

Announcing Gordon's acceptance, SAE Dinner Committee Chairman C. C. Dybvig pointed out that the General Motors' president has been an SAE member since 1943, having joined shortly after he had become chief engineer of Cadillac.

1960 SAE President Harry E. Chesebrough, general manager of Chrysler's Plymouth-DeSoto-Valiant Division, and 1961 SAE President-elect A. A. Kucher, Ford's vice-president-Engineering, will also speak at the dinner, Dybvig said.

Facts . . .

from SAE literature

SIXTEEN NEW AEROSPACE DOCUMENTS and 39 aeronautical material specifications are described in the new booklet titled "SAE Journal in the Aerospacecraft Industries." Included also is an organization chart of SAE Technical Board's Aerospace Council, an outline of what the Council is doing, and a list of its personnel.

SAE Journal will be glad to supply on request one copy of this piece of SAE literature. Address "Literature," SAE Journal, 485 Lexington Ave., New York 17, N. Y.

SAE NATIONAL MEETINGS

1960

- **October 10–14**
  National Aeronautic Meeting including Third AFORS Astronautic Symposium and Aerospace Manufacturing Forum and Engineering Display, The Ambassador, Los Angeles, Calif.

- **October 25–27**
  National Transportation Meeting, Hotel Leamington, Minneapolis, Minn.

- **October 31–November 2**
  National Powerplant Meeting, Sheraton-Cleveland, Cleveland, Ohio.

- **November 2–4**
  National Fuels and Lubricants Meeting, The Mayo, Tulsa, Okla.

1961

- **January 9–13**
  SAE International Congress and Exposition of Automotive Engineering (Annual Meeting), Cobo Hall, Detroit, Mich.

- **March 13–17**
  National Automobile Week (National Automobile and Production Meetings). The Sheraton-Cadillac, Detroit, Mich.

- **April 4–7**
  National Aeronautic Meeting (including production forum and engineering display), Hotel Commodore, New York, N. Y.

- **June 4–9**
  Summer Meeting, Chase-Park Plaza, St. Louis, Mo.

Manly Award Rules Broadened

RULES of the Manly Memorial Medal Award have been changed to provide for the broadening of the Award's scope. The Board of Directors approved the amendments to the rules at its September 20 meeting.

The Manly Memorial Medal Board of Award, upon whose recommendation the rules were amended, felt that the rapidly accelerated progress of aerospace technology required broadening of the Award's scope in order to make more papers eligible. The rules as originally written limited the Award to the aviation powerplants of the prespace era. The first award under the revised rules will be made for the 1961 calendar year.

The following paragraphs detail the changes which were made. The words crossed out were deleted . . . and the words underscored were inserted:

> The Manly Memorial Medal shall be awarded annually to the author of the best paper relating to theory or practice in the design or construction of, or research on, ~~aeronautic power-plants~~ aerospace engines, their parts, components, or accessories which shall have been presented at a meeting of the Society or any of its Sections during the calendar year.

> Papers presented at the Society and Section meetings shall be judged primarily for their value as ~~new contributions~~ a contribution to ~~existing~~ the knowledge of the ~~aeronautic~~ aerospace art. Judgment shall be based upon the value of the paper itself as such an original contribution, not upon the value of some mechanical development or invention already known which the paper may describe.

Student Enrollment Has Built-In Potentials

BACK in the 40's, three "future engineers" applied for Student Enrollment in the Society.

Russell R. Noble was with Lawrence Institute of Technology when he applied for enrollment; Lewis C. Kibbee, with Haverford College; and Gregory Flynn, Jr., with General Motors Institute.

Today, all three are members of SAE's Board of Directors. . . .

Student Enrollment *has* provided the young engineer with the "launching" medium into industry envisioned by the Society when the Student Enrollment classification was established . . . and the percentage of full-membership follow-through is gratifying.

SAE Engineering Students . . . seeking summer employment in 1961

For complete address, write: SAE Placement Service
485 Lexington Avenue
New York 17, N. Y.
Telephone:
OXford 7-3340

Preferred Location	Name, Degree, and Date Available	School and Field of Interest
		BRADLEY UNIVERSITY
Central Illinois	W. W. Claypool BSME '63 — June	Desire summer position in some phase of M. E. to provide practical experience. 3 previous summers' experience in an engrg. office.
Open	John Sulka BS-Auto. Tech. '63 — June	Seek summer job with an auto. mfg. firm which will equip me with res. experience in auto. field. Previous experience in auto. field.
		UNIVERSITY OF BRITISH COLUMBIA
Open	W. D. Worobec BASc(ME) '63 — May	Prefer opportunity with M. E. experience along auto. or aero. line. 2 summers' experience in Caterpillar equipment.
		CALIFORNIA INSTITUTE OF TECHNOLOGY
Open	P. M. Moretti PhD — June	Working towards PhD at Stanford, for some time in '61. 1 summer's experience in vibrations analysis & res. at an advanced level. Eloquent expression in English & German.
		CALIFORNIA STATE POLYTECHNIC COLLEGE
Open	J. C. Kodak BSME '62 — June	Desire work in some phase of machine or tool design. 1 summer's experience in drafting.
		CARNEGIE INSTITUTE OF TECHNOLOGY
Open	R. L. Baker BS-Met. '63 — June	Desire summer job which might be first step in equipping me for responsible work as mfg. supv., sales, or any type managerial work in metallurgical engrg.
		CASE INSTITUTE OF TECHNOLOGY
Europe or Cleveland, Ohio	B. T. Ketcham BSME '62 — June	Desire summer job where I can obtain experience in res. & dev. of internal combustion engines or auto. suspension systems. Have practical experience.
Cleveland	Raymond Knauss BSME '62 — June	Desire work in maintenance, production or design. 2 summers' experience in assembly & machine tool work.
Dayton area	J. S. Noss BSME '63 — June	Desire summer job with company mfg. automobile components. Seeking practical M. E. experience along automotive lines. 4 yrs. amateur experience.
Cleveland	F. D. Berkopec BSME '62 — June	Desire summer work providing experience along automotive lines; no previous experience along these lines in industry to date.
Cleveland	M. J. Bauer, Jr. ME '62 — June	Prefer work with design engineers.
		CITY COLLEGE OF NEW YORK
New York City	William Wu BSME '62 — June	Seek position which might be first step in equipping me for responsible work as design engr.
		DETROIT INSTITUTE OF TECHNOLOGY
Anywhere	B. G. Bodiya BSME '62 — June	Would like a drafting job or any other job connected with engrg.

Continued on next page

Free service to employers and members

SAE Engineering Students . . .

. . . seeking summer employment in 1961.

(continued)

Preferred Location	Name, Degree, and Date Available	School and Field of Interest
Michigan	John Megdan BSME '61 — June	Desire part-time employment in medium-sized mfg. company (automation machinery). Interested primarily in a training program that will eventually lead to Process Engr. position. 3 summers along with 6 mos. experience in machine design.
Detroit	R. V. Schneider BSME '62 — June	Seek summer job with design or testing section.
Detroit-Windsor area Open to Ont.	K. P. Straky, Jr. BSEE '62 — June	Desire summer employment dealing with electronics. Seek position which may equip me with responsibility & understanding for future use as an electrical (high freq.) engr.
		UNIVERSITY OF DETROIT
Open	Claude Cellich MBA '62 — June	Desire training with computers & operations research.
		ECOLE POLYTECHNIQUE
Canada	V. Martel Engr. '63 — June	Prefer opportunity in medium-sized company doing design work.
Open	M. Marchand Engr. '64 — May	Prefer summer job in some phase of metallurgy. No experience.
Open	J. G. Lorrain BScA(ME) '62 — May	Desire experience in auto. engrg. leading to mgmt. responsibility.
		FENN COLLEGE
Cleveland	Steve Siket BS Chem. '64 — June	Desire work as lab technician in petroleum company or automotive firm.
		UNIVERSITY OF ILLINOIS
Open	G. D. Kucaba BSME '62 — June	Desire summer job with company mfg. automotive equipment.
Open	G. Bueso BSME '62 — June	Desire some job working with design of machinery, IC engines or turbines.
		LAWRENCE INSTITUTE OF TECHNOLOGY
Detroit area	Jon Barrett BSEE '63 — June	Desire summer employment that will give me further experience in the electrical engrg. field.
		MICHIGAN COLLEGE OF MINING & TECHNOLOGY
Open	L. J. Doyle BSME '63 — June	Desire summer job in auto. or machinery line which might be first step in equipping me for position of design engr. upon graduation.
Open	M. R. Eberl ME '63 — June	Interested in summer job pertaining to auto. engrg. Presently working for B. S. degree in M. E.
		MISSOURI SCHOOL OF MINES & METALLURGY
Open	D. E. Netter BSME '62 — June	Interested in res. & dev. or design engr.

Free service to employers and members

Preferred Location	Name, Degree, and Date Available	School and Field of Interest
		OKLAHOMA STATE UNIVERSITY
Any	R. L. Tempero BS '62 — June	Want summer experience in auto. field that could lead to permanent employment, preferably in res. & dev.
Southwest U. S.	G. F. Avritt BSME (AD Auto. Tech. AD Diesel Tech.) '62 — June	Prefer work as apprentice Auto. Engr. in field of engines or drive lines. 2 yrs. experience as Chevrolet Mechanic. Current overall grade point of 3.05 based on 4-point system.
		PENN STATE UNIVERSITY
Open	D. R. Weisel BSIE '62 — June	Desire summer work that will provide experience in field of production engrg.
		UNIVERSITY OF PITTSBURGH
Open	D. A. Salisbury BSME '62 — May	Capable young man seeks employment related to design and/or production of heavy indus. machinery.
Open	L. J. Cohen BSME '62 — May	Prefer anything in automotive line.
Open	S. Skibo BSME '62 — May	Prefer position in auto. or aircraft industry. Quality control work preferred. 1 summer's experience.
		POLYTECHNIC INSTITUTE OF BROOKLYN
N. Y.-N. J.	L. Spadaccini BSME '62 — June	Seek position that will offer practical experience in basic Mech. or Indus. Engrg. Also interested in draftsman work.
		PURDUE UNIVERSITY
Central N. Y. State	B. G. Davis, Jr. BS '63 — June	Seeking summer employment in areas of indus. mgmt. or engrg., especially in the auto. or aero. fields.
		QUEEN'S UNIVERSITY
Open	J. C. Singlehurst B. S. '62 — June	Desire experience along auto. or aero. lines, preferably in design or testing field.
		SAN DIEGO STATE COLLEGE
Open	W. A. Theis BS '64 — June	Prefer summer work doing design for experience as design engr. 3 summers' work experience.
		STEVENS INSTITUTE OF TECHNOLOGY
Open	D. P. Wojtowicz BS '63 — June	Prefer summer work in some phase of auto. field. 2 summers' experience.
N. Y.-N. J. area	E. L. Post ME '62 — June	Desire a summer position with a company associated with aero. or auto. industries, which will give me experience in design & res. of either reciprocating engines, jet engines, or their components.
		WAYNE STATE UNIVERSITY
Detroit	P. Hendrickson BSME '62 — June	Desire job leading to position in IC engine design or design of power transfer mechanisms.
Detroit area	P. Colandrea EE '62 — part-time now	Desire work leading to position connected with use of electronics in auto. research, testing or production. 3 yrs. experience in military service as electronic technician.

SAE MEMBERS

THEODORE P. WRIGHT, who has retired as vice-president of Cornell University in charge of Sponsored Research, is retaining two other positions with the University. He will remain as chairman of the Board of the Cornell Aeronautical Laboratory in Buffalo and as chairman of the Executive Committee of the Cornell-Guggenheim Aviation Center in New York City.

A Past SAE Director, Wright served in important government positions during World War II, after an outstanding career in the aircraft industry as an engineering executive. He directed the development of the Curtiss Tanager in 1929, which won the $100,000 prize offered by the Daniel Guggenheim safe-aircraft competition.

PYKE JOHNSON was honored recently by his alma mater, University of Denver, with a Doctor of Public Service Degree "in recognition of his civic achievements and contributions to public service."

Many such citations have come to Johnson since he started his career in the highway transport field. Among them have been honorary Doctor of Laws degree from Kenyon College; a citation by the National Commission on Safety Education of the National Education Association; an honorary citation by his native State of Colorado; the award of the Legion of Honor by the French Government; and the George S. Bartlett Highway Award for service to the Clay Commission which produced the "Grand Highway Plan" enacted into law in 1956.

JOHN R. NEFF has been named director of product development for S I Handling Systems, Inc. in Philipsburg, N. J. Formerly he was employed by Chrysler Corp. as supervising engineer for Missile Division.

LESLIE F. LITTLE is now a consultant on cross country transport and earthmoving vehicles — having retired as director and chief engineer of Vickers-Armstrongs (Tractors) Ltd., Newcastle upon Tyne, England.

Little joined the Vickers-Armstrongs organization in 1928, where he has been associated continuously with the design and development of civil and military tracked vehicles.

During World War II, he was seconded to the British Ministry of Supply, where he served as deputy director of tank design.

PHILIP A. SCHEUBLE, JR. has been elected a vice-president of Vapor Heating Corp. He will continue his present position as general manager of the company's Vap-Air Division.

THOMAS L. APJOHN has been named manager of additives department in the Paint and Special Products Division of Mobil Chemical Co., a new operating division of Socony Mobil Oil Co., Inc. Previously he served Mobil's overseas operation as manager of its petroleum chemicals department.

STUART C. McCOMBS has retired as administrative vice-president of Chicago Rawhide Mfg. Co., after serving the company for 40 years.

McCombs started Chicago Rawhide's activities in the Detroit area with a small sales office in 1921, and has been instrumental in the development of their activities in the area.

A. K. PARRISH has been named assistant to the general manager of Thompson Products Michigan Division, Thompson-Ramo-Wooldridge, Inc. He had been assistant general sales manager of the Michigan Division for the past year and a half.

H. J. BUTTNER has joined the executive staff of Homelite, a division of Textron, Inc. as vice-president and staff assistant to the president. Buttner has been working with Homelite in a consulting capacity during the past year.

WILLIAM H. HALL has been elected assistant vice-president of service engineering for American Airlines, Inc. He had been director of service engineering since November, 1959.


Neff


Scheuble


Apjohn


McCombs


Buttner


Hall

ROBERT CASS, (center) president of SAE in 1953, has moved to Portland, Oregon, where he will be a Lecturer in engineering at University of Portland's School of Engineering.

Cass retired recently as assistant to the president, White Motor Co. He had been with White for 35 years and served in many important capacities, including that of chief engineer.

On August 17, Cass was honored at a retirement dinner, where **ROBERT F. BLACK** (left), chairman of the Board, and White President **JOHN N. BAUMAN** (right) were the hosts.

JOHN V. PRESTINI has been appointed sales manager for wheel products at The Budd Co., Automotive Division. He had been responsible for Budd's sales relationships with Chrysler Corp.

R. L. CLARK, works manager at Ryan Aeronautical Co.'s San Diego plant since 1956, has been named vice-president — works manager.

ROBERT GARMEZY has been appointed director of engineering at Blackstone Corp. Gamezy joined the company in 1951 and has set up and directed the test facilities for Blackstone's heat transfer products.

ALLEN FREDHOLD, executive vice-president and general manager of Hadco Engineering Corp., has been elected to Hadco's board of directors.

JAMES W. MARTIN has been appointed works manager of Bucyrus-Erie Co.'s plant operations at South Milwaukee, Wis. He had been assistant to the vice-president, engineering, since December, 1956 and had also supervised the company's Engineering Standards Division.

DR. W. WAI CHAO has been appointed director of research and development at Vickers, Inc., division of Sperry Rand Corp. Dr. Chao joined Vickers in 1959 as chief of research.

V. E. BOCCELLI has been appointed project engineer for the recently organized Skybolt Re-entry Vehicle Program at General Electric Co.'s Missile and Space Vehicle Department. He joined the department in 1958 as planning engineer for the Re-entry Vehicle Projects Operation.

NELSON R. DROULAND had been named technical director of mechanical and nuclear engineering at Franklin Institute Laboratories, Philadelphia. He had been research and development director of Budd Co.'s Automotive Division.

ROBERT E. DAVIES has been named technical manager in molded goods for B. F. Goodrich Industrial Products Co. He had been project engineer on passenger tire development for B. F. Goodrich Tire Co. since 1957.

CECIL N. KING has been appointed general manager of U. S. personnel and chief consultant for Acinfer, S. A. in Argentina. Formerly he was manufacturing engineer for Chrysler International in Argentina.

JOHN W. CARLSON has been appointed assistant general manager of Allis-Chalmers Mfg. Co.'s Construction Machinery Division. He had been general manager of the Deerfield Works since Allis-Chalmers acquired the Illinois firm (formerly Tractomotive Corp.) about a year ago.

JAMES B. CODLIN succeeds **John W. Carlson** as general manager of Allis-Chalmers Deerfield Works. His former position was chief engineer at the Deerfield Works.

WILLIAM A. MacFARLAND has been named senior design engineer for Lockheed Aircraft Corp.'s Missiles & Space Division. Formerly he was chief engineer for defense products at Brown & Sharpe Mfg. Co.

DUANE T. McRUER, president of Systems Technology, Inc. will receive a Louis E. Levy Medal from The Franklin Institute at their annual Medal Day ceremonies, October 19.

The award is presented to the author of a paper of special merit, published in the Journal of the Franklin Institute. McRuer and Ezra S. Krendal of Franklin Institute Laboratories Laboratories each won awards for their joint paper on "The Human Operator as a Servo System Element."

EARLE F. COX has joined American-Marietta Co. as general research engineer in charge of new machinery development for Concrete Products Division. Formerly he served Blaw-Knox Co. as project engineer.

Prestini

Clark

Garmezy

Martin

Chao

Drouland

JOHN G. MATALON has joined Hancock Industries, Inc. as project engineer. Previously he served AGT Division of Westinghouse Electric Corp. as senior engineer.

PHILIP M. STRONG, formerly an engineer for Dynamic Developments Inc., is now development engineer at Torrington Mfg. Co.

ALBERT W. FOSTER has been appointed chassis design supervisor for Wettlaufer Mechanical Engineering Division of Pioneer Engineering & Mfg. Co. Formerly he was engine design engineer for Chrysler Corp.

ROBERT E. LOREN has become field engineer for Pratt & Whitney Aircraft Co. Formerly he was application engineer for General Electric Co.'s Small Aircraft Engine Department.

ROBERT E. THOMAS has become aeronautical power plant engineer at Wright Air Development Center, Wright Patterson Air Force Base, Dayton, Ohio. Formerly he was project engineer for Allison Division, General Motors Corp.

OSCAR A. LEVI has been appointed project engineer for flight test at Gyrodyne Co. of America. Previously he served Republic Aviation Corp. as flight test project leader.

R. EDWARD LODICO, previously research technologist for Socony Mobil Laboratories, is now service engineer at Ohio Oil Co.

ROBERT E. SCHMITT, previously development engineer for Thompson-Ramo-Wooldridge, Inc., has joined the TRW subsidiary Ramsey Corp. as project engineer.

K. C. GIFFEN has joined Burch Corp. as assistant to the president. Previously he was president of Gifeo, Inc.

PAUL J. JUNG, previously chief test engineer, is now chief engineer for Trailmobile, Inc. at Berkeley, Calif.

EDWARD D. HENDRICKSON, previously secretary and sales manager, is now executive vice-president of Hendrickson Mfg. Co.

WILLIAM M. CADE is now division chief engineer at International Harvester Co.'s Farm Equipment and Engineering Center at Hinsdale, Ill. He had been chief engineer at the company's product engineering department.

NORRIS C. BARNARD, manager of shallow draft marine sales for Esso Standard Oil Co., has received the Boating Man of the Year Award" for 1960. The award is given annually by the Marine Trades Association of New York.

LUTHER W. FEAGIN, formerly senior director (SAGE), Washington Air Defense Sector, Ft. Lee, Va., is now commander at Resolution Island, N.W.T. for the U. S. Air Force.

RICHARD HUTTON, vice-president for engineering at Grumman Aircraft Engineering Corp., is recipient of the Lawrence Sperry Award for "outstanding contributions to the development of carrier-based aircraft."

ELWOOD H. ROBINSON has been appointed manager of lubricant and grease sales for Lion Oil Co. Division of Monsanto Chemical Co. Formerly he was assistant manager for lube oil sales.

CHARLES R. PLUM has been named director of marketing for Amcel Propulsion, Inc. Formerly he served American Air Filter Co. as general manager.

DONALD H. McGOWN has joined International Harvester Co. as sales engineer. Previously he served Aramco Overseas Co. as supervisor of transportation section.

R. W. ELLIS has joined Universal Sales & Service, Ltd. in Alberta, Canada as service manager. Previously he served Healy Motors, Ltd. in a similar capacity.

F. KRAAY has become overseas service inspector for Van Doorne's Automobiel Kabrieken N. V. in Holland. Formerly he was technical manager for N.A.M.V. in the Belgian Congo.

Obituaries

BENJAMIN N. ASHTON . . . (M'49) . . . retired president of Electrol, Inc. . . . died August 17 . . . born 1904.

ADNA R. CLARK . . . (M'59) . . . design engineer, advanced engineering, International Harvester Co. . . . died May 5 . . . born 1905.

WILLIAM COX . . . (M'42) . . . vice-president, chairman of the board, Elco Lubricant Corp. . . . died July 10 . . . born 1904.

E. P. DeBERRY . . . (M'59) . . . northwest fleet manager, Studebaker-Packard Corp. . . . died May 9 . . . born 1913.

COL. E. A. DEEDS . . . (M'11) . . . retired chairman of the board, National Cash Register Co. . . . died July 1 . . . born 1874 . . . developed, in association with Charles F. Kettering, the modern automobile ignition, starting, and lighting system . . . credited with conceiving idea of electrifying cash registers . . . during World War I, instrumental in development of Liberty engine, America's first war produced airplane engine.

VICTOR JANTSCH . . . (M'12) . . . retired . . . died July 27 . . . born 1887.

DANIEL H. KELLY . . . (M'24) . . . management consultant for D. H. Kelly Associates (now E. J. Kelly Associates) . . . died July 26 . . . born 1883.

WARREN J. KOPF . . . (M'57) . . . assistant technical director, Elco Lubricant Corp. . . . died July 12 . . . born 1923.

RAY MANSMANN . . . (M'44) . . . chairman of the board, G. M. Schnabel Co. . . . died May 29 . . . born 1888.

EMIL R. MARTEN . . . (M'46) . . . engine designer, White Diesel Engine Division, White Motor Co. . . . died July 16 . . . born 1929.

MAURICE B. MILLER . . . (M'52) . . . propietor, Aeronautical Service Engineering . . . died July 14 . . . born 1905.

MAJOR WILLARD G. PALM . . . (M'54) . . . aircraft commander, maintenance officer, Department of the Air Force . . . died July 1 . . . born 1921.

CLARENCE H. PARRISH, JR. . . . (M'52) . . . product engineer, senior designer, Ford Motor Co., Engineering Staff . . . died June 17 . . . born 1912.

RALPH POGSON . . . (M'57) . . . owner, Hanna Auto Specialists . . . died July 22 . . . born 1903.

OTIS PRESBREY . . . (M'23) . . . president, Otis Auto Dynatester, Inc. . . . died July 9 . . . born 1890.

JOHN W. SMITH . . . (M'18) . . . research engineer . . . died May 16 . . . born 1871 . . . during World War I, member of National Advisory Committee for Aeronautics . . . designed and built first successful steel propeller, now in Smithsonian Institute.

CURTIS GARWOOD TALBOT . . . (M'53) . . . manager, Flight Test Operations, General Electric Co., Schenectady . . . died Aug. 8 . . . won GE's Coffin Award in 1951 for his "unusual initiative, energy, technical ability and sound judgment in the flight testing of aircraft." . . . Born Plymouth, Ill. in 1913 . . . BS in Electrical Engineering, University of Illinois . . . Joined GE shortly after graduation in 1936. . . . Licensed commercial pilot.

F. H. TURNER . . . (M'40) . . . manager of Power & Industrial Equipment Division, General Motors New Zealand, Ltd. . . . died May 11 . . . born 1909.

WILLIAM G. WEST . . . (M'24) . . . retired . . . died July 7 . . . born 1892.

GERSON ZWEIGHAFT . . . (M'58) . . . thermodynamics engineer, Republic Aviation Corp. . . . died July 22 . . . born 1937.

SAE Section Meetings

BALTIMORE

November 10 . . . Frederick R. Gruner, director of engineering and Herbert L. Forman, engineer-in-charge, Engineering Laboratories, Purolator Products, Inc. "Recent Development in Air, Fuel, Lubricating Oil and Hydraulic Oil Filtration." Engineers Club, 6 West Fayette Street. Dinner 7:00 p.m. Meeting 8:00 p.m.

DETROIT

November 7 . . . John Z. DeLorean, assistant chief engineer, Pontiac Motor Division, General Motors Corp. "The Pontiac Tempest." Rackham Educational Memorial, 100 Farnsworth. Dinner 6:30 p.m. Meeting 8:00 p.m. Dinner Speaker: Paul Goldsmith.

FORT WAYNE

November 9 . . . John S. Worthington, Ethyl Corp. "Potential Automobile Powerplants." Hobby Ranch House, Corner Anthony & Crescent Aves. Dinner 6:30 p.m. Meeting 8:00 p.m.

METROPOLITAN

November 1 . . . F. N. Dickerman, assistant chief engineer, Stratos Division, Fairchild Engine & Airplane Corp., Bay Shore, New York. "The Lockheed BLC Hercules — A Practice STOL Transport." Stratos Division, Fairchild Engine & Airplane Corp., Bay Shore. Plant Tour 5:30–6:30 p.m. Sponsored Cocktails 6:30–7:00 p.m. Dinner 7:00 p.m. ($3.00 per person) Meeting 7:45 p.m. Special Feature: Films and Slides will be shown.

November 10 . . . "Small Diesels for New York Truck Fleets." Representatives from International Harvester Co. and Detroit Diesel Division of GMC. Brass Rail Restaurant, Fifth Ave. between 43rd & 44th St., New York. Cocktails 5:30 p.m. Dinner 6:30 p.m. Meeting 7:45 p.m.

November 17 . . . James M. Smith, manager, automotive section, Aluminum Co. of America, "Aluminum Engines." Henry Hudson Hotel, 57th St. & Ninth Ave., New York. Meeting 7:45 p.m.

NEW ENGLAND

November 1 . . . C. E. Killebrew, vice president, Clark Equipment Co. "Off Highway Equipment." M.I.T. Faculty Club, Memorial Drive, Cambridge. Dinner 7:00 p.m. Meeting 8:00 p.m.

PITTSBURGH

October 25 . . . I. N. Bishop, Ford Motor Co. "Fuel Economy — What is the Potential?" Mellon Institute Auditorium, 4400 Fifth Av. Dinner 6:00 p.m. Meeting 8:00 p.m.

ST. LOUIS

November 15 . . . Col. John Hernden, commanding officer, Aeronautical Chart Service. "Navigational Aids for Space Travel." Congress Hotel, 275 Union Blvd., St. Louis. Dinner 7:00 p.m. Meeting 8:00 p.m.

SALT LAKE

October 31 . . . H. A. Bowles, manager of marketing, Western Region, Continental Oil Co. "Oil Industry Magic." Prudential Federal Savings Bldg., 33rd South and State St. Dinner 7:00 p.m. Meeting 8:15 p.m. Special Feature: "Doc" Bowles amateur "Magician".

SOUTHERN CALIFORNIA

November 7 . . . Panel Meeting discussing "New M-S Test Sequence." Union Oil Auditorium, 461 So. Boylston, Los Angeles. Meeting 7:00 p.m.

November 14 . . . Elvin S. Wright, test pilot, North American Aviation. "X-15 Experimental Rocket Plane." Rodger Young Auditorium, 936 W. Washington Blvd., Los Angeles. Dinner 6:30 p.m. Meeting 8:00 p.m.

TEXAS SECTION

November 17 and 18 . . . 7th Annual Auto Air Conditioning Forum.

SAE's

Is at

AN SAE STUDENT BRANCH is now in operation at Milwaukee School of Engineering by virtue of a charter granted at the June meeting of SAE's Board of Directors.

The new Branch starts out with 75 enrolled students . . . and with more than a year's operating experience as an SAE club. While under Club status, one plant-inspection tour and seven technical meetings were held — all well attended.

Among the enrolled students who worked in various officer capacities to launch and bring the Club to Student Branch status are: Robert Ginnow, Russell Graf, George B. Gross, Keith W. Hammel, Gerald Oja, Robert Prochaza, Norman Stieber and Henry Thompson.

Keith F. Kummer has been faculty advisor since the Club's inception, and will continue in that capacity for the Student Branch. J. P. Kelly, Milwaukee Section Student Committee chairman, and F. B. Esty, Sections Board member on the Student Activities Committee, have been valuable Section and headquarters links for Faculty Advisor Kummer and the students. Word comes from the students that, with the assistance of all three, an active Student Branch year is in the making.

About the School

Founded in 1903 by Oscar Werwath, and chartered by the State of Wisconsin in 1917, MSOE is governed by a 15-man Board of Regents elected from among 59 eminent representatives from industry, commerce, engineering, and education — who form the non-stock corporation of MSOE. Karl C. Werwath is currently president; Heinz M. Werwath, vice-president and treasurer; Fred J. Van Zeeland, dean of engineering.

The "Concentric Curriculum"

At MSOE, some 2100 students are studying technology under a unique system known as the "concentric curriculum." This system makes possible the educating of both engineers and engineering technicians simultaneously . . . and provides a natural succession of courses leading through an Associate in Applied Science degree to a Bachelor of Science degree. The concentric cur-

Newest Student Branch

Milwaukee School of Engineering

riculum gives students opportunity to progress through nine months of basic technical studies, then study at the engineering technician level, and eventually to the 36-month engineering level.

The student may elect to study in either electrical or mechanical technology. Technician programs are available in air conditioning, computer, electrical power electronics communications, metallurgical and industrial technology. Graduates of either of these programs are granted Associate in Applied Science degrees and have completed the first 18 months prerequisite study for the Bachelor of Science degree in either electrical or mechanical engineering. (SAE enrolled students are drawn from among those in the latter category.)

Four inherent advantages claimed for the MSOE system are:

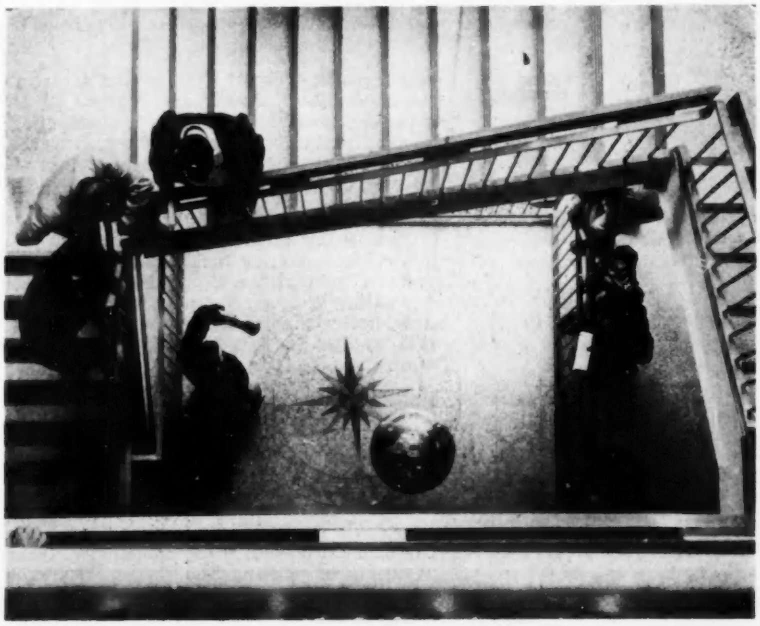
1. Progress during the first nine months of basic study determines the potential of the student. With this background, he is better able to decide whether his capabilities will permit him to complete engineering technician or engineering studies, or both.
2. Technical subjects are introduced during these first months of study. These subjects, combined with electives in other areas such as the humanities and social sciences, give MSOE graduates the fundamental requirements for successful careers as engineering technicians or engineers.
3. Teaching both the engineering technician and the engineer on the same campus gives each a better understanding of the part the other plays on the engineering team . . . and leads to a closer liaison and cooperation between the two groups in industry.
4. The system is oriented toward the more mature student — the student who has already decided that his career potential is greatest in the field he is pursuing at MSOE.

The School's curriculums are under constant surveillance by a team of expert industrial advisors, who suggest revisions and changes to meet changing industrial requirements . . . and industry supports MSOE through capital gifts and equipment to gear the instruction as closely as possible to the needs of industry.

KEITH F. KUMMER, chairman of the mechanical engineering department at Milwaukee School of Engineering, is Faculty Advisor for the SAE Student Branch.

A native of Wauwatosa, Wis., Kummer served three years in the United States Navy during World War II, and graduated from the University of Wisconsin in 1951. He has been a member of the Mechanical Engineering Department at the Milwaukee school for the past six years.

Kummer



The Focault Pendulum — a feature of MSOE's Allen-Bradley Hall of Science — is a continuing demonstration of the direction of the earth's motion. This phenomenon has important application in long-range missiles and the study of atmospheric circulation. Milwaukee's latitude is 43.03 deg north. Consequently, the floor beneath the pendulum is marked off in 34 units of 10.236 deg, which is the hourly rotation rate for this location. Here a group of students in the main stairwell check the pendulum's swing.

SAE's CEP News

COOPERATIVE ENGINEERING PROGRAM

12 New SAE Aero-Space

APPROXIMATELY 35,000 SAE Aeronautical Standards pass into the hands of engineers in aerospace industries each year. This flow of performance and design information is being increased by the recent issue of 12 new SAE documents . . . which has been linked with the revision of eight existing reports.

Name of New Document	Purpose	Originating Committee
Identification Marking of Items for Aircraft Powerplants (AS 478)	Specifies marking methods which identify propulsion components. Covers both permanent marking for normal service life and temporary marking for identification and/or record of inspection up to time of initial assembly or use. Allows a designer to specify a particular marking method or a class of marking methods which are of approximately equal severity. The class option enables suppliers to use existing equipment.	Committee E-21, Design and General Standards for Aero-Space Propulsion Systems
Aircraft Circuit Breaker and Fuse Arrangement (ARP 486)	Sets forth the desired location and arrangement of circuit breakers, fuses, and limiters in civil-type multi-engine transports . . . thus eliminating the possibility of errors during flight such as the physical inversion of these protective devices and their associated equipments.	Committee S-7, Cockpit Standardization
Hose Assemblies, Flexible Metal, Aeronautical, Low Pressure (ARP 601)	Specifies requirements and basic qualification tests of flexible low pressure metal hose assemblies used in aircraft to convey fuels, lubricants, coolants, and bases in fuel systems, bleed air systems, heating and ventilating systems, cooling systems, anti-icing systems, fire extinguishing and instrument air systems. Also applies to hydraulic and pneumatic system drain lines.	Committee G-3, Aircraft and Missile Fittings and Flexible Hose Assemblies
Hose Assemblies, Flexible Metal, Aeronautical, Medium Pressure (ARP 602)	Same as above except it applies to medium pressure hose assemblies.	Same as above.
Tapered Axle Collar Dimensions (AS 665)	Specifies dimensions for tapered axle collars used in aircraft.	Committee A-5, Aircraft Wheels, Brakes, Skid Controls, and Axles
0-Ring Size and Part Number Cross-Reference Chart (AIR 63)	Provides a ready cross-reference between ARP 568, Uniform Dash Numbering System for O-rings, and a variety of existing and former dash numbering systems called out in other O-ring drawings and standards.	Committee G-4, Elastic Seals

NOTE: An Index of SAE's Aeronautical Standards, Recommended Practices, and Information Reports is available free of charge from SAE Headquarters, 485 Lexington Ave., N. Y. 16, N. Y.

Equipment Expert Joins Technical Board

Dolan

J. H. DOLAN has joined the SAE Technical Board at the invitation of SAE President Chesebrough. His duties as a member of this group will be to help formulate policy for some 300 technical committees which produce hundreds of documents each year.

Dolan entered the automotive industry through the construction field. In World War II, he was an equipment officer with construction battalions in Alaska and the Pacific. His post-war experience began at Morrison-Knudsen Co. Subsequently, he worked as a service engineer at Mack Trucks and at Burlington Truck Line as general manager-mechanical. His current affiliation with the Brown Trailer Division of Clark Equipment Co. began in June of this year.

Dolan has been active in Transportation and Maintenance Technical Committee work as well as that of three of its subcommittees.

Reports Up Total to 282

Fitting End: Attachable, Male for 37° Flared Tube Connection, Flexible Metal Hose — Straight, 45° Elbow and 90° Elbow Styles (AS 1011)	Sets forth the critical installation dimension when assembled to flexible metal hose for the fittings described in the drawing title.	Committee G-3, Aircraft and Missile Fittings and Flexible Hose Assemblies
Fitting End: Attachable, Swivel Female 37° Machined Flare, Flexible Metal Hose — Straight, 45° Elbow and 90° Elbow Styles (AS 1012)	Same as above.	Same as above.
Fitting End: Attachable, Swivel Female 37° Flared Tube, Flexible Metal Hose — Straight, 45° Elbow and 90° Elbow Styles (AS 1013)	Same as above.	Same as above.
Fitting End: Attachable, Swivel Flange, Flexible Metal Hose — Straight, 45° Elbow and 90° Elbow Styles (AS 1014)	Same as above.	Same as above.
Fitting End: Attachable, Female Flareless, Machined Nipple, Flexible Metal Hose — Straight, 45° Elbow and 90° Elbow Styles (AS 1015)	Same as above.	Same as above.
Fitting End: Attachable, Flareless Male, Flexible Metal Hose — Straight, 45° Elbow and 90° Elbow Styles (AS 1016)	Same as above.	Same as above.

Revised Documents

ARP 277A — Propeller attachment — Nose Mounted
AS 278A — Cockpit Flight Instrument Panel Arrangement (Inactive for New Design of Transport Aircraft, Effective June 1, 1960)
ARP 368B — Spark Plug Thread Form Data (60° Thread Angle)
AS 393A — Airspeed Tubes Electrically Heated
ARP 483A — Anti-Skid Equipment
ARP 494B — Terminals — Input and Output — Ignition Exciters
AIR 32A — Cockpit Visibility for Commercial Transport Aircraft (Inactive for New Design of Civil Transports, Effective June 1, 1960, See ARP 580)
AIR 84A — Ignition Peak Voltage Measurements

To order the above, see p. 6

A. T. COLWELL (left) predicted in his dinner talk that "the standard sized car is going to get smaller and the compact is going to get bigger." Following introduction by Toastmaster C. A. Winslow (right), Colwell went on to prophesy that:

(1) The hump in passenger cars, caused by transmission and drive shaft, will eventually disappear.

(2) A practical solution will be found for the exhaust emission problem.

(3) Gas turbines and free-piston engines are in their infancy. They will be most applied in off-highway vehicles and trucks.

(4) The horsepower race — which is ended among larger cars — will continue among compacts.

(5) Some forward-thinking inventor may likely pioneer an invention that obsoletes our present powerplants.

Colwell, who is vice-president of Thompson-Ramo-Wooldridge, is an SAE past president and is currently chairman of SAE's Finance Committee.

1960 West Coast Meeting

Technical Papers . . .

The California Motor Vehicle Emission Standards by **C. S. Hass**, State of California, Dept. of Public Health **(210A)**

Approaches to the Direct Flame Afterburner by **C. W. Cornelius**, Holley Carburetor Co. **(210B)**

The Need for a New Concept of Rapid Transit by **W. N. Kennedy and W. S. Homburger**, Institute of Transportation & Traffic Engineering, University of California **(210C)**

Directional Stability and Control of a Four-Wheeled Vehicle in a Flat Turn by **Martin Goland and Frederick Jindra**, Southwest Research Institute **(211A)**

Full Scale Testing of Highway Rails and Median Barriers by **F. N. Hveem and J. L. Beaton**, State of California, Division of Highways **(211B)**

Crash Studies of Modern Cars with Unitized Structure by **R. H. Fredericks and R. W. Connor**, Ford Motor Co. **(211C)**

Head-On Collisions — Series III by **D. M. Severy, A. W. Siegel, and J. H. Mathewson**, Institute of Transportation & Traffic Engineering, University of California **(211D)**

Diesel — Gas Turbine Power by **C. G. A. Rosen**, Consultant **(212A)**

Electrochemical Fuel Cell for Transportation by **M. Eisenberg**, Lockheed Missiles & Space Division **(212B)**

Gas Turbine Cycles and Design Concepts for Vehicle Propulsion by **C. H. Paul and E. L. Kumm**, AiResearch Mfg. Co. of Arizona **(212C)**

Designing Off-Highway Mobility The Problem and the Answer Past and Present, Future by **W. M. Brown and V. H. Dorsey**, Kenworth Motor Truck Co. **(213A)**

Design and Muskeg Operation of the 20-Ton Payload Carrier, the Musk-Ox by **C. J. Nuttall, Jr.**, Wilson, Nuttall, Raimond Engineers, Inc., and **J. G. Thompson**, Imperial Oil, Ltd **(213B)**

High-Speed Tractor Steering Transmissions by **H. W. Christenson**, Allison Division, General Motors Corp. **(213C)**

The Electric Transmission for Railroad Locomotives by **T. B. Dilworth**, Electro-Motive Division, General Motors Corp. **(214A)**

Dieselhydraulic Locomotives by **K. W. Lampe**, Krauss-Maffei AG **(214B)**

Crank-Piston Gas-Generator Locomotives by **Lars Tengner**, Aktiebolaget Gotaverken **(214C)**

Diesel Development in Medium and Small Commercial Applications by **J. G. Dawson**, F. Perkins, Ltd. **(215A)**

The Development of the Small Automotive Diesel in Western Europe and Its Likely Role in the USA by **J. H. Pitchford**, Ricardo & Co., Ltd. **(215B)**

Papers are available through SAE Special Publications Department. Prices: 50¢ a copy to members; 75¢ a copy to nonmembers.

SECTIONS OFFICERS LUNCHEON during the West Coast Meeting saw seated at a head table (left to right) W. F. Ford, chairman of the SAE Sections Board; Harry E. Chesebrough, SAE President; I. M. Harlow, chairman, Northern California Section; and Joseph Gilbert, SAE secretary and general manager.

Speaking at the West Coast Meeting dinner later, President Chesebrough cited the success of recent changes in SAE organization which allow more members to contribute to and participate in the Society's activities. Among other things, he told his audience were: "If life were dull, I wouldn't want any part of it" . . . and "One of the toughest jobs an engineer has to do is to sell."

At the conclusion of his dinner remarks, President Chesebrough presented a plaque to J. A. Edgar, general chairman of the West Coast Meeting, for his part in organizing the highly successful program.

Reaches New Technical Highs

THREE days of timely, well chosen and interesting technical sessions, a sellout banquet affair, planned activities for the ladies, and a visit to Aerojet General Corporation's facilities at Sacramento to see what's involved in making Titan and Polaris missile boosters, resulted in a most successful SAE National West Coast Meeting at the Jack Tar Hotel in San Francisco, August 16–19, 1960.

Total attendance was near the 500 mark; and individual session attendance averaged 185.

"Smog" Problems Again

Two sessions continued and brought up to date SAE's coverage of the technical aspects of the "smog" problem. In the past year, the State Legislature of California took significant steps toward control of vehicle exhaust emission by setting allowable limits for hydrocarbons and carbon monoxide. The new State regulations provide also for eventual installation of approved motor vehicle pollution control devices.

Also revealed at the meeting was a promising approach to the control of smog-producing vehicle-exhaust emissions through a direct flame afterburner. Such devices are claimed to have passed the development and research stage and are being readied for possible production. It is expected, however, that their general acceptance might be resisted because of high initial and operating costs, noise, and possible fuel economy. A slight amount of extra gasoline is needed for the operation of this device.

A less direct approach to controlling automobile air pollution is through development of new rapid transit concepts. These ideas were discussed by engineers from the University of California. To replace the highway congestion and associated problems, such as smog-causing emissions resulting from providing "rapid mass transit" to main population areas via the automobile, a new system requiring a vehicle having the flexibility of a manually operated bus has been suggested. Such a vehicle, as it approaches the downtown congested areas would be put on special track systems which would provide for automatic control and deliver passengers rapidly and safely to their destinations within the heart of the city with convenience and ease.

A more novel, and perhaps unconventional, suggestion to relieve modern day traffic congestion was to make better use of passenger cars (which often haul only one or two persons), by setting up a system whereby individuals, after establishing required qualifications, would be allowed to pick up and haul passengers for revenue in their own cars.

Technical Sessions Interest

Other technical sessions of the meeting developed data on what happens when your car hits a dividing barrier on the highway. They discussed questions like: "Am I safer in the modern unitized car than in the conventional body and chassis construction?" . . . and, "What happens when cars meet head-on at better than 50 mph?"

A lot of these questions were answered during the sessions on highway safety. Motion pictures of actual crashes of cars and buses into road barriers and into each other were one of the more interesting highlights of these sessions.

At a session on "New Power Sources" someone hazarded a guess that, if all goes well, we might see fuel cells powering some highly specialized vehicles in 5–10 yr. It will be some time, however, before this source of power will make an appreciable impact on the passenger car transportation field.

At present, the gas turbine does not appear to offer sufficient advantages to merit it as a replacement for the reciprocating engine in passenger cars. Some feel its application to automotive transportation may never come, while

A DISTINCT FOREIGN FLAVOR characterized this 1960 West Coast Meeting . . . and previewed in miniature the SAE International Congress and Exposition of Automotive Engineering scheduled to be the 1961 Annual Meeting in Detroit next January.

Prominent among the overseas participants in the West Coast Meeting assembled by Program Chairman E. S. Starkman of University of California, were (left to right) Lars Tengner, Aktiebolaget Gotaverken; J. H. Pitchford, Ricardo & Co., Ltd.; Starkman; and J. G. Dawson, F. Perkins, Ltd.

Present also were Antonio Mora, Consultant, Instituto Nacional de Tecnica Aeronautica, Madrid, Spain; M. Arantelovic, and M. Pecic, Yugoslavian Railways, Belgrade; H. Bata, coordinator, Esso France.

FIVE SECTIONS were sponsors for the 1960 West Coast Meeting. Their chairmen (left to right): J. F. Beach (So. California); S. G. Jones (British Columbia); Louis Schroeder (Northwest); I. M. Harlow (No. California); and Mel Gordon (Oregon).

others feel it may be only 5 yr in the future. Utilization and further development of exhaust-driven supercharger turbines to existing successful powerplants may well encourage the further development of more efficient gas turbines and a transition stage to the development of a full gas turbine powerplant.

Transport Problems

The Musk-Ox vehicle can carry a payload of 20 tons; weighs a total of 45 tons. Yet in moving along on its special wide tracks it exerts, under full load, a pressure of only 3.1 lb per sq in. This light-footed vehicle was specially designed for oilfield operations in the muskeg terrain (marsh-like peat bogs) in Canada. It is the only type of vehicle that has been able to transport needed equipment to work sites during the seasons when the muskeg is not frozen.

Color motion pictures showing this unusual vehicle in operation under most adverse conditions were shown. Not only was the vehicle unusual, but so was the film. It seems the authors, in their haste to make a good showing for their presentation, had some additional feet of excellent film spliced into the reel at the last moment — upside down and backward.

Diesel Locomotives

Of the 30,500 diesel electric locomotives operating in the United States, all have used DC electric transmissions. In contrast to this wide U. S. experience, are the diesel-hydraulic locomotives developed in Germany by Krauss-Maffei AG. This German design is powered by lighter-weight, higher-speed diesel powerplants than is the current practice in the U. S., and — as the name implies — uses a Voith hydraulic transmission drive for transmitting the power to the driving wheels.

Details of the European locomotive development were discussed during the "Railroad Powerplants and Drives" session by P. Garen of the Southern Pacific Railroad, substituting for K. W. Lampke, of the Krauss-Maffei organization, who was unable to attend. Krauss-Maffei locomotives are scheduled to be given a field trial in the U. S.

exposed when re-entering or flying is presented on two axis remote atti-

J. A. EDGAR (front row center) was general chairman for this 1960 SAE West Coast Meeting.

Serving with him as chairmen of the various committees through which successful operation was achieved were (left to right): Front row — I. M. Harlow (House); E. B. Lien (Finance); Edgar; E. S. Starkman (Program); and C. R. Coffey (Publicity). . . .

Back row — D. C. Wimberly (Banquet); E. C. Beagle (Transportation); C. W. Frankenfield (field editor); R. E. Totman (Ladies Activities); C. E. Bull (Registration & Reception); and V. C. Peterson (Arrangements).

soon. Three each of the 4000 hp units have been ordered by the Southern Pacific and the Denver-Rio Grande and Western Railroads. It is expected that this light weight, high powered locomotive will allow up to 5% increase in payload in U. S. railroad service.

A locomotive design that requires no torque converter transmission was described by L. H. Tengner of Aktiebolaget Gotaverken, Goteborg, Sweden. A gas turbine driving the locomotive requires only a speed reducer and reversing gear to attain the desired speed-torque characteristics for this application.

The unusual feature of this locomotive design is the gas turbine. The diesel gas generator consists of a 5-cyl, 2-stroke opposed-piston engine with only one crankshaft. The lower piston is connected by a short rod to a middle bearing of the crankshaft, the upper piston by two long rods to the side cranks adjacent to the middle bearing. Single acting compressor pistons are connected by intermediate yokes to the upper working pistons. The gas generator operates in the speed range of 360 to 720 rpm and develops 1300 gas hp.

High-Speed Diesels

At the final session of the meeting J. F. Dawson of F. Perkins, Ltd. and J. H. Pitchford of Ricardo & Co., Ltd. discussed the current status of development of the medium and small high-speed diesel for automotive applications. Although the United States has lagged behind Europe in using the diesel in smaller trucks, vans and commercial vehicles, the authors predicted that diesel engines will be the coming means of powering taxis and service vehicles. They feel, however, that widespread use in passenger cars in not very likely. In some trial applications of diesel-powered taxicabs on the West Coast, gains of 100% in fuel consumption over the conventional gasoline powered taxicabs have been observed. The main objections to use of diesels in cabs are noise, low power and inherent roughness. Some diesels have been tried in taxicab service in San Francisco but were discontinued because they lacked sufficient power to provide satisfactory performance over the hilly terrain there.

To provide further acceptance of the light weight high speed diesel for automotive service throughout the world, development of less restrictive wider cut diesel fuels has been suggested.

Representatives from England urged that the automotive and oil industries get together on extensive cooperative programs to develop engines and fuels that can operate over a wider range than possible today. The hope was expressed that in the future it would be possible to have a broad-band fuel, possibly not too dissimilar from JP-4, for use in all commercial fuel applications including heating, except for the spark ignition engine. The future possibility of requiring only two fuels, gasoline and diesel, would facilitate greatly distribution problems. This Utopian state of affairs was believed, however, to be at least 10 yr in the future.

Banquet

At the Wednesday night banquet, after a thoroughly enjoyable social hour, approximately 270 members, guests and wives assembled in the main banquet room of the Jack Tar Hotel.

A FIELD TRIP to Aerojet General Corp. near Sacremento, Calif., closed the West Coast Meeting. The visitor viewed the research and manufacturing facilities of this large rocket component manufacturer. (Aerojet produces parts for the Polaris, Minute-Man, and Titan missile engines.)

During the trip, there was an actual firing of the third stage of a Titan liquid-fuel missile. Nearly fifty SAEers saw this spectacular event. (The third stage of the Titan develops 300,000 lb of thrust and consumes about 350 lb of fuel . . . and 900 lb of oxygen per second. The firing lasts 140 sec.)

Theoretical Prediction of Effect of Goodrich Co. Research Center in tire ments; hydraulic and servo systems,

Briefs of SAE PAPERS

continued from p. 6

comparison of air breathing booster to rocket booster.

New Diet for X-15 Engine, G. R. CRAMER, H. A. BARTON. Paper No. 177C. Design concepts which make rocket engine suitable for manned space vehicles also provide wide range of performance capabilities through use of different propellants; outline of unusual possibilities resulting from propellant substitutions using XLR-99 turbo-rocket engine, developed for X-15 research aircraft; four propellant combinations are oxygen and hydrazine, oxygen and hydrogen, nitrogen tetroxide and hydrazine, and hydrazine and pentaborane; results obtained.

Ablation Cooling of Missiles and Satellites, E. R. G. ECKERT. Paper No. 185A Physical processes involved and basis on which evaluation of ablation cooling to protect missiles during re-entry through atmosphere can be made; conditions to which object is exposed when re-entering or flying with hypersonic velocities; overall heat balance considering re-entry process can give first information on amount of heat sink material required; for detailed design study, heat balances have to be made for each instance during re-entry time; pertinent equations.

Plasma Propulsion, S. W. KASH. Paper No. 185B. Underlying principles of plasmas and plasma phenomena; in plasma propulsion units, neutral plasma is accelerated with aid of electric and magnetic fields; magnetic fields can be provided by currents in plasma, or independently; propellant energy is supplied by electric fields; however, magnetic fields are required to orient gas and give it net momentum; steady-state and pulsed plasma-accelerator involve some basic principles although technical problems are different and analog to those between d-c and a-c electrical devices; pertinent equations.

Pilot Instrumentation for Vehicle Control in Near Space, C. J. HECKER. Paper No. 173C. Study of mission program composed of escape, exo-atmospheric, and recovery phase; performance boundaries for escape problems, and tolerances on orbit injection conditions; since vertical orientation, velocity along path and altitude are quantities which determine successful exit, conventional instrumentations appear adequate; vertical orientation is presented on two axis remote attitude indicator; velocity along path and altitude are displayed on 3-in. indicators; other instruments.

Turbofan and By-Pass Type Engines for Jet Transports, A. A. LOMBARD, D. GERDAN. Paper No. 172C. First Conway engine and development of running of RB. 141 engine; parameters which determine suitability of engine are installed fuel consumption, power plant weight and bulk, and engine cost; arangement of Rolls-Royce by-pass engine; thrust reversing device is integral part of engine; geometric layout; advantages to be gained by operating at high turbine inlet temperatures; effect of turbine inlet temperature and by-pass ratio on operating economics is shown.

GROUND VEHICLES

Engineering Know-How in Engine Design — 8, Paper SP-178. Eighth of series of annual lectures planned by Milwaukee Section consists of following papers: Techniques in Evaluating Valve Train Dynamics, L. T. BRINSON, Jr., 13 p.; Dynamometers for Engine Testing, T. E. JAHNTZ, 19 p.; Radio-Isotopes — New Testing Tool, Z. J. RACZKOWSKI, 16 p.; Instrumentation for Engine Testing, I. BAXTER, 16 p.; Techniques Used in Field Testing Diesel Engines, J. J. CYCHOL, Jr., 9 p. See also seventh of series indexed in Engineering Index 1959 p. 109.

Computer Simulation of Automotive as Nylon, rayon, acetate, wool and cot-

Theoretical Prediction of Effect of Traction on Cornering Force, W. BERGMAN. Paper No. 186A. Theory, substantiated by tire road tests, carried out by Ford Motor Co., explains effect of traction on cornering force by using new concept of spring interaction; good correlation found between calculated and test data; major factors determining effect of power application on cornering force established are reduction of overall lateral stiffness of tire, and reduction of effective lateral coefficient of friction; effect of vertical load and application of tire theory to evaluation of vehicle handling.

Experimental Determination of Effect of Traction on Cornering Force, C. A. FREEMAN, Jr. Paper No. 186B. To substantiate calculation methods for predicting these effects, experimental determination of traction force-cornering relationship was required; details of practical track test procedure, instrumentation developed and tests conducted at Ford Motor Co.; measurements required relate to tire slip angle, lateral tire force, axle to frame force of right and left side, towline tension and angle, and car speed; schematic of lateral tire force wheel.

Tread Wear Operating Variables and Index Determination, J. L. GINN, R. L. MARLOWE, R. F. MILLER. Paper No. 186C. Approach used by B. F. Goodrich Co. Research Center in tire testing program to predict how new tread compound or construction will affect tread life of tires in hands of customers; discussion is devoted to study of tread wear resulting from "pure" severities; vehicle was operated at low speeds straight ahead for low values and under severe cornering for high values; individual effect of some of operating variables.

Mechanics of Tire Squeal, R. F. MILLER, J. G. SLABY. Paper No. 186D. Reductions in squeal were made by changes in tread profile, tread compound, and changes in load distribution; results of studies made by B. F. Goodrich Co. Research Center, to obtain more information about movements in contact which give rise to squeal-producing vibrations; experimental techniques used; it is shown how squeal accompanies sliding in lateral recovery portion of cornering contact; presence of buckled region in cornering and its relation to squeal.

European Approach to Braking Standards, C. W. JACKMAN. Paper No. 184C. Scope of work of Economic Commission for Europe and contributions made toward international cooperation in road transport and standardization of safety devices; brake equipment is divided into single line, direct and indirect, single line indirect with added supply line, and American 2-line system; other brake developments; hydraulic and servo systems, disk brakes, passenger car brake requirements, exhaust brakes and transmission fitted retarders; main features of proposals for braking regulations.

Should Engine or Engineer Get Last 5 Horsepower?, M. F. STERNER. Paper No. 199A. Problems brought out by upgrading engine horsepower in favor of customer's satisfaction vs. best engineering design; advantages and disadvantages in meeting each of these objectives.

Forecasting Specific Fuel Economy, P. M. CLAYTON. Paper No. 199B. Approach taken by Ford Motor Co. consists of determining vehicle power required at flywheel and adding computed friction to obtain indicated horsepower vs. engine speed; indicated specific fuel economy is then determined which, when combined with indicated horsepower, vehicle velocity, and fuel density, yields miles per gallon; problem of method used to obtain engine friction and indicated specific fuel economy; details of solution.

International Model 817 High Output Diesel Engine, D. J. BUNDY, E. H. STROMBERG. Paper No. 198A Features of turbocharged, open chamber, direct injection, 4-stroke cycle diesel engine, developed to meet construction equipment requirements; 6-cyl in-line configuration has 5⅜-in. bore and 6-

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Advanced Automotive Gas Turbine of line tire inventory commences with problems shows that they can be cured

Briefs of SAE PAPERS

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in. stroke, resulting in total displacement of 817 cu in.; crankshaft of C-1046 steel forging with BHN of 248–285 is mounted in seven bearings; piston is aluminum casting; crankcase design, gear train, fuel system, cooling and lubricating oil system; performance data.

Problem Associated with Windscreen Wiping, J. S. CLARKE, R. R. LUMLEY. Paper No. 197A. Problem of aerodynamic effect of wind forces on wiper blade arising with increasing speeds and advent of wrap-around windshields; results of water tunnel tests on scale models of vehicles and flow patterns observed; aerodynamic tests in rectangular duct which simulates air flow conditions over surface of windshield forms useful technique for comparing performance of various blade forms; materials; torque requirements and three suitable transmission types; motor and gear box.

Computer Simulation of Automotive Fuel Economy and Acceleration, R. K. LOUDEN, I. LUKEY. Paper No. 196A. Applications of vehicle simulation programs at Buick Motor Div.; paper reports development of mathematical model which could accurately predict acceleration and economy; method of analysis used and equation development for two cases; technique for computing automobile highway fuel consumption consists of four steps which are outlined; instrumentation for road test data.

Computer Predicts Car Acceleration, H. L. SETZ. Paper No. 196B. Approach used at Ford Motor Co., to obtain desired characteristics for acceleration performance and development of fundamental relationships; differential equations defining translatory motion of passenger car; graphical description of method employed to evaluate integrals expressed; evaluation of performance equations; computer solution techniques; performance prediction system applications; data processing flow chart and computer output tabulation; prediction system accuracy and cost data.

How Textiles Increase Your Horsepower, R. T. CHATHAM, Jr. Paper No. 193A. In automobile upholstery field there are three types of fabrics used: piece, yarn, and solution-dyed, each of which has certain advantages; development of new fabrics and designs, such as Nylon, rayon, acetate, wool and cotton; requirements which automobile fabrics must meet with respect to crocking, shade, dye stability, fading, abrasive testing, and seam strength.

Development of Cylinder Water Seal to Prevent Diesel Engine Crankcase Cavitation Erosion, A. B. NEILD, Jr. Paper No. 191A Failures of several crankcase designs studied at U. S. Naval Eng. Experiment Station; test procedure involving use of soft test plugs for rapid evaluation of possible corrective measures required for 600-hp aluminum crankcase; development of special cylinder liner water seal, with seal bands of different Paracril BLT compounds; seal strength was adequate for at least 3000-hr engine operational periods.

Fuel Injection and Postive Ignition — Basis for Improved Efficiency and Economy, C. W. DAVIS, E. M. BARBER, E. MITCHELL. Paper No. 190A. Combustion process for reciprocating engines, developed by Texaco Research Center, uses coordinated arrangement of fuel injection, positive ignition and air swirl; high thermodynamic efficiency and operating economy are achieved through ability to burn lean mixtures and use broad boiling range fuels having no octane or cetane requirements; method of operation, design requirements and performance of experimental 2- and 4-stroke-cycle engines.

Advanced Automotive Gas Turbine Engine Concept, I. M. SWATMAN, D. A. MALOHN. Paper No. 187A. Philosophy applied by Ford Motor Co. in developing gas turbine for heavy trucks centered around search of different cycles; component efficiencies used in cycle analyses and cycles investigated; cycle comparison and part-load investigation; near constant-speed feature of h-p spool combined with almost constant reheat-burner temperature and varying air-flow characteristics of l-p spool produced excellent part-load fuel economy in cycle n 11; engine using this cycle is under development.

Film Vaporization Combustor, A. W. HUSSMANN, G. W. MAYBACH. Paper No. 187B. Concept of film vaporization which led to invention of M-system for diesel engines; study carried out at Pennsylvania State Univ. to apply same principle to gas turbine combustors; following elements were retained: fuel is spread as film on wall of "vaporizer tube"; primary air flow through tube with vigorous swirl; walls are kept relatively cool and heat of evaporation is taken from combustion itself by means of recirculating combustion products in core of air swirl; design of prototype.

Tire Branding and Inventory Control, R. KUPP. Paper No. 200C. Method used at Consolidated Freightways Corp., Avon Lake, Ohio, operating fleet of trucks and trailers; control of line tire inventory commences with branding of each tire into service; rolling stock of tires is constant with type and number of line vehicles in service; physical count is made only of spare or service stocks and tires being processed through tire reconditioning shops; forms and records used; trailer interchange practices as set up by Nat. Equipment Interchange Committee.

Motions of Skidding Automobiles, H. S. RADT, Jr., W. E. MILLIKEN, Jr. Paper No. 205A. Program, carried out by Cornell Aeronautical Laboratory shows that simple analysis of lateral skidding of automobile is practical, that mathematical model will predict experimentally verifiable skidding characteristics and may be used for either simulation or calculation purposes; with usual assumptions for separating lateral (handling) behavior from longitudinal (ride) behavior, it is possible to write equations of motion of automobile; computer solutions are discussed.

Cures for Powerplant Bending Noise Problems, R. H. BOLLINGER, J. H. RUHL. Paper No. 203A. Powerplant bending is oscillatory bending or "beaming" of structure formed by engine block, clutch housing, transmission, and transmision-extension, occurring in vertical plane of vehicles equipped with conventional Hotchkiss or torque tube drivelines; study carried out by Ford Motor Co. to identify noise problems shows that they can be cured by modifying one or more of following: vibration input, drivetrain structure and mounting, and body (or chassis).

How to Keep Small Fleet Sparkling, R. L. FISKE. Paper No. 204A. Requirements of cleaning compound and light washing equipment and devices designed to apply compounds most efficiently; model 226-092 "500" Hydra-Clean, developed by Oakite Products, and wash-all power-spray, foam unit; recommended procedure.

Are You "Married" to Right Vehicle Washer?, M. LEWIS, S. MINDLIN. Paper No. 204B. Paper deals with wash rack equipment of type where vehicle is stationary and equipment itself moves to facilitate washing of vehicles; four basic types are described: inverted "U" type with 2 lines of plumbing and with 1 line of plumbing; inverted "L" or wand type and square frame that travels vertically; advantages and disadvantages of rinser type wash equipment.

Choosing Equipment for Large Wash Rack Installation, C. P. ROSS, R. W. BURRILL. Paper No. 204C. Basic vehicle cleaning methods, and how they are used on large vehicles and on heavy production basis; factors to consider in selecting washing methods and type of equipment, such as determining sizes, shapes and number of vehicles

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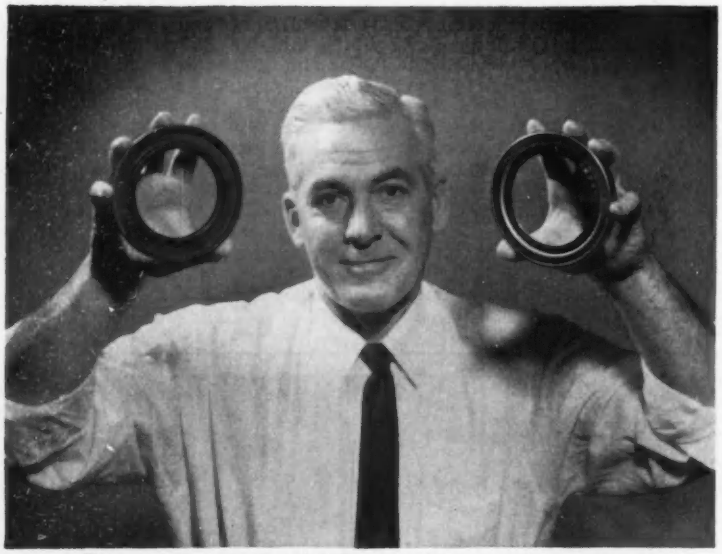
OIL SEALS

In Design Engineering



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when your

based on present lubricants, it is thought that common transmission and

Briefs of SAE PAPERS

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to be washed; location of rack, water drainage and electric supply, types of equipment available for washing and drying, how equipment operates, approximate cost of each, hourly production and limitations and advantages.

Influence of Tires and Their Variables on Passenger Car Skidding, A. H. EASTON. Paper No. 205B. Paper represents summary of highlights of First International Skid Prevention Conference held in Sept. of 1958 and discusses various papers presented under following headings: effect of tread design, of carcass construction and tire size, tread composition, and effect of load, inflation and speed.

Recent Developments In Cam Design, J. H. NOURSE, R. C. DENNIS, W. M. WOOD. Paper No. 202A. Analytic method for automotive engine cam design wherein design procedures for considering elastic deflections in valve train are extended to include problems of maximizing breathing efficiency; cam design goals and limitations and five interdependent variables involved; summary of polydyne method for cam design; be means of flow chart, perspective of mathematical steps involved is given; computer work; how desired boundary conditions in optimal cam profile design solution are achieved.

Engine Mountings—Automotive Workhorses, G. KLAASEN. Paper No. 203B. Examination of methods which can be used to best qualify engine mountings for their role involve mounting locations, dynamic stiffness of mounting in three directions and damping of mounting; factors to be considered, such as effect of frequency on location of engine bending nodes, effect of damping on vibration transmission, undesirable characteristics of conventional rubber mountings, etc.

From 4 Plies to Single Ply in Steel-Cord Casing Tires, M. P. BAUMONT. Paper No. 200A. Problem of tire temperature, especially for Giant truck tires used on long hauls; research work done at Michelin, Clermont-Ferrand, France, in developing X-tire or Radial ply steel-cord casing tire; details of steel-cord technique applied; advantages include increased load carrying capacity and running speeds; increase in tread life and excellent "road-behavior" of vehicle and tire grip even on snow and ice.

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Cord Fatigue in Fleet Tested Tires, W. G. KLEIN, M. M. PLATT, W. J. HAMBURGER. Paper No. 200B. Progress report on nature of cord fatigue, carried out by Fabric Research Laboratories, Dedham, Mass.; study deals with properties of cords and filaments removed from tires run on New York taxi fleet; emphasis was on Tyrex viscose cord, but nylon was included; results indicate that there is initial loss of cord strength of 10–15% within first 20,000 mi., followed by period of gradually diminishing strength; while there is trend for small loss in fiber strength with mileage, it is not correlative with cord strength losses.

Aluminum Castings for Passenger-Car Engines — Comparison between USA and Europe, A. F. BAUER. Paper No. S258. Describes use of aluminum in passenger-car engines, both here and abroad, with emphasis on die-cast engine blocks, use of cast-in gray iron liners, hypereutectic Al-Si alloys, plastic bonding of aluminum castings, transplant coated cylinder barrel.

Rotating Combustion Engine, R. T. HURLEY. Paper No. S236. Background and history of rotating engine; German Wankel engine principle, and NSU-Wankel experimental engines; thermodynamic and gas cycle and performance of engine; nine experimental engines of single rotor type with 60 cu in. displacement, built by Curtiss-Wright Corp. having license and engineering assistance agreement with NSU and Wankel; engine components and cycle sequence; features include elimination of valve difficulties, freedom from vibration, simplicity, small size and high efficiency.

FUELS & LUBRICANTS

Laboratory and Field Findings Pertaining to Axle Lubricants, W. A. JOHNSON. Paper No. 192A. Field experience gained at Rockwell-Standard Corp. shows that SAE-140 viscosity lubricant is far superior to SAE-90 in preventing gear wear; other lubricant factor which merits attention involves load carrying ability of lubricant; transmision recommendations generally specify SAE-90 viscosity and absence of load carying additives; it is suggested that lubrication requirements and recommendations for transmisions are different from those for rear axles.

Report on Transmision Lubricant Requirements, R. E. FLETCHER. Paper No. 192B. Lubricant requirements of truck and bus transmissions; based on present lubricants, it is thought that common transmission and rear axle lubricant do not constitute best lubricant; results obtained in laboratory tests made with three SAE 90 Hypoid gear lubes, three MIL-L-2105 or MIL-L-2105B multi-purpose gear lubes, and three SAE 50 heavy duty engine oils; effort should be made to develop common transmission and engine lubricant rather than transmission and axle lubricant.

Comparison of Axle and Transmission Lubricant Requirements, R. K. NELSON, L. J. VALENTINE. Paper No. 192C. Paper compares requirements for motor truck transmissions and rear axles in relation to operational standards; major factors are load carrying requirements, operation temperatures, rolling and sliding velocities, and lubricant properties; comparison shows distinct variations and similarities; it is in regard to load carrying ability that further study is important in developing lubricants compatible for transmission and rear axle operations.

Practicality of Common Transmission and Axle Lubricant, S. R. CALISH. Paper No. 192D. Common lubricant was used for transmissions and axles of heavy duty equipment since 1947 and optimum base oil-additive combination was selected based on extensive laboratory and field tests; latest military specification requirements emphasize antiscore protection at expense of other desirable qualities; extent of successful field experience is statistically substantiated; paper represents view point expressed by California Research Corp.

Friction of Transmission Clutch Materials as Affected by Fluids, Additives, and Oxidation, J. J. Rodgers, M. L. HAVILAND. Paper No. 194A. Study made at General Motors Research Laboratories to investigate relationship between friction and automatic transmission operation; fluids, fluid oxidation, additives, and clutch plate materials were investigated; it is found that both fluids and additives have appreciable effect on friction characteristics; with respect to clutch plate materials, differences in friction characteristics were observed.

Radioactive Tracer Study of Lubricating Oil Consumption, E. S. STARKMAN. Paper No. 194B. Reciprocating engine lubricating oil consumption usually is determined by differential method of measurement; tritium tracer-scintillation counter technique was used by Univ. of Calif. to tag oil and to count activity of exit routes by which oil or its degradation products leaves engine; theory for abnormal oil consumption shows relationship between consumption and engine speed and load.

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Metallic Tracer Method for Determining Lubricant in Engine Exhaust, F. R. BRYAN, J. C. NEERMAN, J. E. HINSCH. Paper No. 194C. Method, applied at Ford Motor Co., consists of tracing lubricant additive through engine and detecting it quantitatively in exhaust by using alkali metal as tracer and flame photometry as means of detection; flame excitation of exhaust sample provides sufficient sensitivity of detection and rate of lubricant loss can be instantaneously recorded; using sodium, time lag was 2 sec.

Consideration of Deposit Ignition Mechanism, R. W. BOWDITCH, T. C. YU. Paper No. 201A. Deposit and hot spot ignition resistances of fuels were measured and compared at General Motors Research Laboratories; ignition resistances are found to be dependent upon type of surface causing ignition; ignition mechanism involving concepts of ignition temperature and flammability limits is proposed to explain differences in ignition resistances between fuels and ignition sources; proposed mechanism is consistent with known facts on surface ignition.

Concurrent Pyrolytic and Oxidative Reaction Mechanisms in Precombustion of Hydrocarbons, C. E. WELLING, G. C. HALL, J. S. STEPANSKI. Paper No. 201B. Ford Motor Co. study relates synthetic hydrocarbon products from motored engine with precombustion reaction such as cracking, hydrogen stripping, and peroxide formation and decomposition; reaction paths run concurrently and originate from common reactant, original free radical produced by abstraction of hydrogen atom from fuel molecule; reaction path may be chain mechanism that maintains concentration of original common free radical reactant.

Unsteady Heat Transfer in Engines, V. D. OVERBYE, J. E. BENNETHUM, O. A. UYEHARA, P. S. MYERS. Paper No. 201C. Thermocouple, whose junction is located 1μ below surface of combustion chamber wall of CFR engine, was used at Univ. Wisconsin to record metal surface temperature as function of time; data were taken deliberately keeping thermocouple free of deposits and deliberately building them up; first procedure gave instantaneous heat transfer rates permitting evaluation of coefficients in unsteady heat transfer; second shows that deposits from different fuels have different effects on heat transfer.

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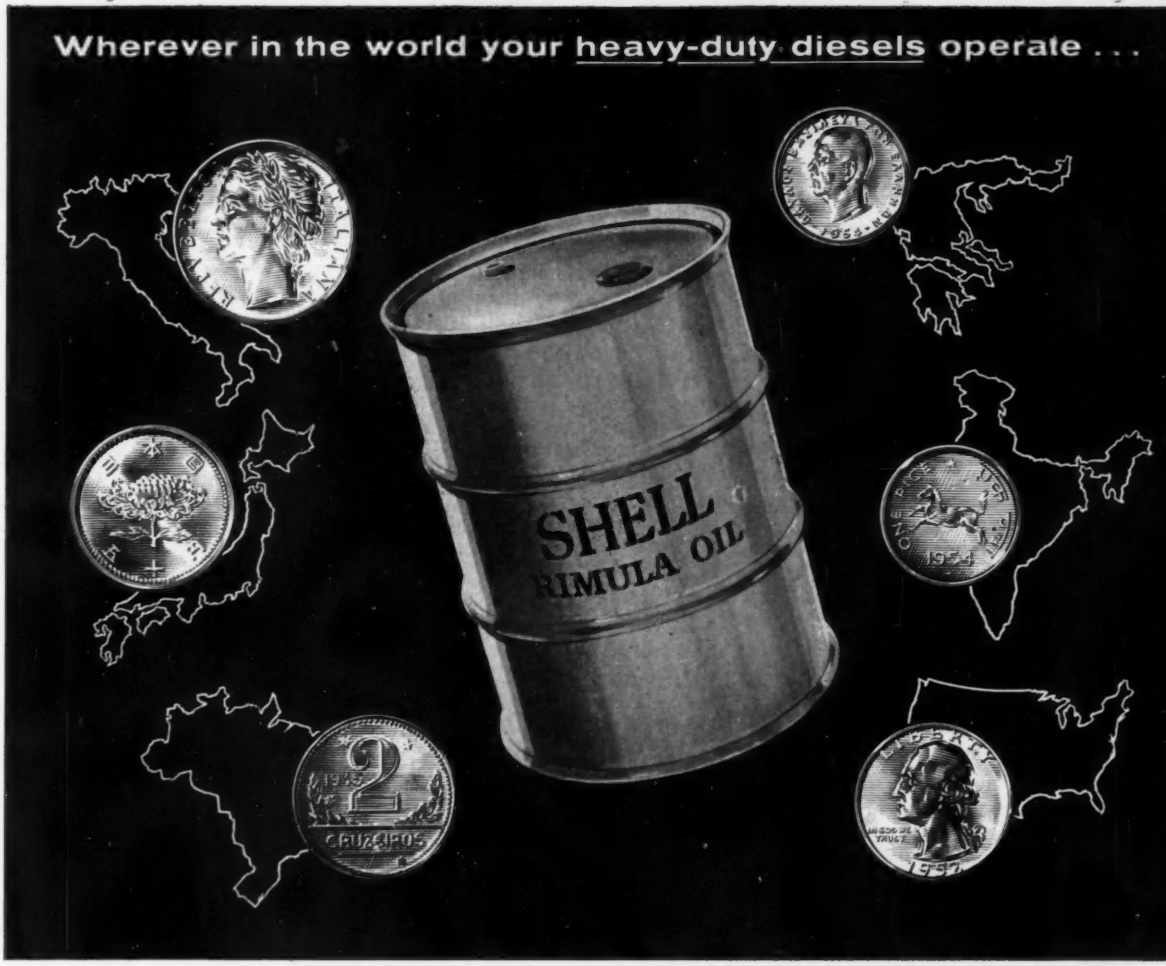
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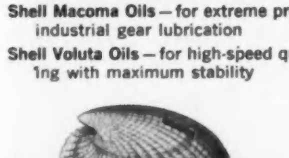

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End-Gas Temperature Measurement by Two-Wavelength Infrared Radiation Method, W. G. AGNEW. Paper No. 201D. Under sponsorship of CRC three methods of engine end-gas temperature measurement were studied at MIT and Univ. Wisconsin; General Motors Research independently carried out study of 2-wavelength method; details of method and how it is applied; experiments with motored air and fired engine; advantages of method recommend it over over techniques, although its significant contribution appears to be its use as independent source of information.

Measurement of Unburned-Gas Temperature in Engine by Infrared Radiation Pyrometer, M. C. BURROWS, S. SHIMIZU, P. S. MYERS, O. A. UYEHARA. Paper No. 201E. Techniques developed under CRC sponsorship; sound-velocity, iodine absorption, and infrared radiation pyrometer methods; details of latter; temperature time histories obtained by other two instruments; pyrometer, using water vapor as sensing medium and null method of data recording, for measuring gas temperatures to plus or minus 5 R as demonstrated by steady flow system.

End-Gas Temperature-Pressure Histories and Their Relation to Knock, M. E. GLUCKSTEIN, C. WALCUTT, P. R. ACLES. Paper No. 201F. Measurements in CFR engine using speed of sound and balanced-pressure techniques; it was found that, for given knock-limited operating conditions, fuels of different octane level and type provided relatively constant final end-gas temperatures of 1840 plus or minus 40 R; pressure values varied from 200 to 700 psia; results show that previous hypotheses are not consistent with observed data.

PRODUCTION

Effects of Support System and Stylus Radius on Roughness Measurement, F. W. KABAT, C. H. GOOD. Paper No. 195A. Reference made to ASA Standard B46.1-1955 on Surface Roughness, Waviness and Lay with respect to stylus tip radius, shape, and shank angle; at Micrometrical Manufacturing Co., Ann Arbor, Mich., tests were taken on Proficorder using styli with radii from .0001 to .250 in.; it is concluded that it is not fineness of surface which requires sharper stylus,

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but other characteristic which could be included angle of scratches; grinding wheel grit could have smaller included angle.

Roundness and its Ramifications, E. E. LINDBERG. Paper No. 195B. Concept of roundness as it relates to journal, ball and roller bearings, shafts and bores, surfaces that run in contact with seals, etc.; use of iso-diametric surfaces; roundness measuring devices and techniques devised to determine out-of-roundnes of machine parts; definition for out-of-roundness has following advantages: when measured from defined center, out-of-roundness can be determined from circular chart, strip chart, or displacement indicator; definition is amenable to instrumentation either manually or automatically operated.

Measurement of Surface Waviness of Rolling-Element Bearing Parts, O. GUSTAFSSON, U. RIMROTT. Paper No. 195C. Principle of waviness testing to evaluate irregularities of surface of rotation; current method of vibration testing; correlation between waviness and vibration; ball waviness tester, applied at SKF Industries, Philadelphia, Pa., consists of true running spindle driven at constant speed of 740 rpm, velocity sensitive pickup, and ball seat; displacement and velocity reading instruments; waviness tests in determining parts responsible for excessive vibrations; calibration method.

Measurement, Evaluation and Specification of Surface Finish of Tubing, W. C. HARMON. Paper No. 195D. Study, carried out by Formed Steel Tube Inst. to find instrumentation capable of accurately measuring inside surface finish; instrument selected operates by tracing inside surface with diamond stylus, carried on skid with radius large enough to provide stable support unaffected by surface variables; stylus is coupled to transducer which generates voltage directly proportional to vertical displacement of stylus; development and application of rotator for mechanical tracing; rating procedure.

How To Improve Plant Layouts, N. L. SCHMEICHEL. Paper No. 189A. Steps involved in engineering plant revision giving emphasis to job shop conditions encountered in automotive parts replacement manufacture; product load analysis breakdown of representative model or type into its subassemblies and component parts to form basis for preparing work route sheet; machine load data for determining requirements planned and capacities available; development of cross charts for solving flow patterns and actual machine work center relationships; economic studies and other aspects.

Economics of Revising Plant Layouts, J. McINTOSH. Paper No. 189B. Principal economic factors to consider when planning change in plant layout; procedure is illustrated by case history concerned with reduction of material handling costs derived from rearrangement of plant facilities and warehousing; tables.

These digests are provided by ENGINEERING INDEX, which each year abstracts 30,000 engineering articles from 1500 different publications and classifies them into 249 "fields of engineering interest."

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Orbital Refueling Drops Weight of Space Vehicles

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and

C. F. YOUNG

Northrop Corp.

VEHICLES for lunar or planetary missions can have significantly lower takeoff weight if they are refueled with upper atmosphere air. This system involves putting into orbit a satelloid whose function is to collect and store air for refueling space vehicles. The satelloid will overcome drag by a plasma-jet with magnetogasdynamic thrust augmentation. A portion of the captured air will feed this plasma-jet.

To put one pound of payload into orbit, based on the state-of-art, the takeoff mass is on the order of 100 lb. By utilizing the upper atmosphere air for space propulsion the saving in takeoff weight is enormous. Air may be used for propulsion as an oxidizer for chemical rockets, or as the reaction mass for nuclear powered propulsion engines.

Upper atmosphere air can be collected and liquefied by a satelloid designed specifically for such purposes. Once such Orbital Refueling Satelloid is put into orbit, a thrust of about 50 lb. is sufficient to keep it in orbit.

This thrust may be furnished by a magnetogas dynamic ram jet which consumes a portion of the intercepted air. The unused portion of air collected is made available to other space vehicles. By utilizing nuclear power, the air collecting satelloid can stay up in orbit almost indefinitely.

■ **To Order Paper No. 230H . . .**
from which material for this article was drawn, see p. 6.

Surface Temperature Variations Measured in an Operating Engine

Based on paper by **Vern D. Overbye,** University of Wisconsin **James E. Bennethum,** GM Research Laboratories **O. A. Uyehara and P. S. Myers,** University of Wisconsin

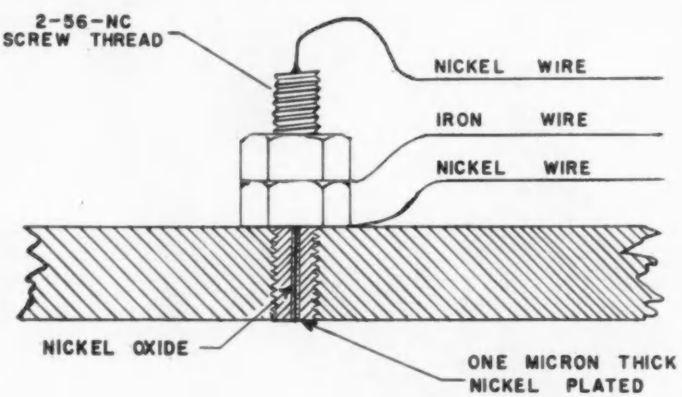

FIG. 1 — Thermocouple construction and installation. Nickel wire is insulated electrically (and thermally) from iron body by nickel oxide film formed on wire. Iron is drawn down on nickel wire by wire-drawing die. After end of resulting concentric cylinders is metallurgically polished, a layer of nickel is evaporated on it; thus, thermocouple junction is located at nickel-iron interface. Nickel evaporation was controlled to give one-micron-thick layer. Lower iron nut, together with iron and nickel wires clamped by this nut, form a second thermocouple. Junction of this thermocouple is located between wall and nut. Its output then is a measure of wall temperature on water side. Iron wire is common to both thermocouples.

Thermocouple records metal temperature at thermocouple junction, which, for present purposes, is same as gas-metal interface temperature.

Thermocouple was modified slightly for tests with deposits to permit easy removal for cleaning and reinstallation.

SURFACE temperature measurements followed by heat-transfer analyses were undertaken for an operating internal-combustion engine. A thermocouple (Fig. 1) whose junction was one micron below the surface of the combustion-chamber wall was used, together with appropriate oscillographic equipment, to give recordings of the combustion-chamber metal surface temperature as a function of time. Data were taken in two ways — deliberately keeping the thermocouple free of deposits and deliberately building up deposits over the thermocouple.

The first procedure, plus suitable mathematical analysis, gave instantaneous heat-transfer rates through the gas-metal interface. This permitted evaluation of heat-transfer coefficients in unsteady heat transfer. The data and analysis suggest that the concept of the heat-transfer coefficient *h* is of questionable utility and validity in unsteady heat transfer.

The second procedure showed that deposits from different fuels have markedly different effects on heat transfer and heat-transfer rates.

Tests without Deposits

The purpose of these tests was to measure the surface temperature variation at three locations in a CFR engine without deposits, and to determine the effect of operating conditions on wall temperature variation. The data were used to determine heat-transfer rates through the combustion-chamber wall surface, and an attempt

continued on p. 134

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Surface Temperature Variations Measured in an Operating Engine

. . . continued from p. 132

was made to correlate heat transfer with operating parameters. Several conclusions may be made from the resulting data:

1. The temperature of the combustion-chamber wall surface varies in minimum temperature level and temperature swing with operating conditions and also location in the combustion chamber. Orientation of the shrouded intake valve affects flame patterns, which in turn affects the rate of wall temperature response and the time in the cycle at which the wall temperature rise occurs.

2. The maximum heat-transfer rates in unsteady heat transfer may differ by as much as a factor of 20 when compared with the steady-state values, that is, the amount of heat actually reaching the cooling water per unit time. This clearly indicates that considerable heat is transferred from the gases to the wall during combustion and expansion and then transferred back to the gases during intake and compression. The steady-state rates vary with location in the combustion chamber, and this affects the instantaneous heat transfer during the cycle.

3. The heat-transfer coefficient concept offers many problems and the correlation of Eichelberg[1] does not agree with experimental results found in this study for either a fired or motored engine. This may be due to the fact that the data used by Eichelberg were obtained in a diesel engine with thermocouples located beneath the combustion-chamber surface, whereas data in this study were obtained with a surface thermocouple in a spark-ignition engine.

4. A theoretical analysis (given in the appendix of the complete paper) suggests a correlation for heat transfer in a mounted engine, which gave quite good results when applied to experimental data. However, the correlating equation[2] could not be reduced to a heat-transfer coefficient equation, which tends to confirm reservations concerning the use of the concept of h. Also, the effect of turbulence on heat transfer could not be accounted for in a single correlation with the experimental data available. This is to be expected since the correlation did not involve turbulence as a variable.

5. A theoretical analysis including chemical reaction could not be completed because of nonlinearities and complexities of the defining equations.

6. Although Eichelberg's equation[1] does not agree with the experimental data of this study, it is a simple expression, and it is an attempt to account for three factors important to heat transfer in an engine, that is (1) turbulence, (2) gas density, and (3) gas-temperature, wall-temperature differences. The present study did not produce a more satisfactory correlation for heat transfer in a fired engine, and our present state of knowledge in this area must be regarded as unsatisfactory.

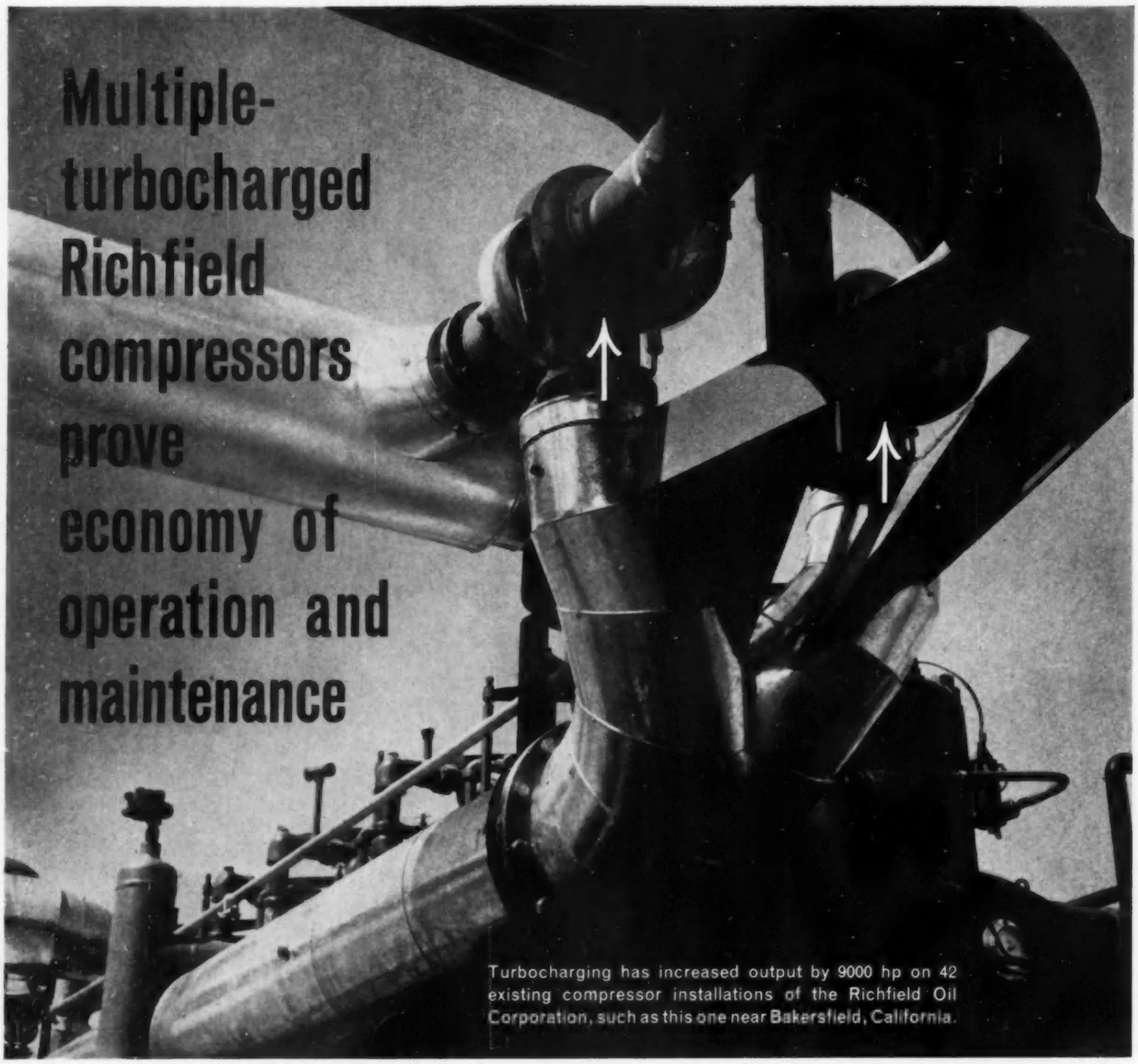
Tests with Deposits

The purpose of these tests was to measure deposit-wall interface temperature variations at two locations in

continued on p. 138

[1] $h = 0.0564 \sqrt[3]{V_o} \sqrt{P T_g}$, where h = instantaneous heat transfer coefficient, Btu/ft²-hr-R; V_o = mean piston velocity, fps; P = gas pressure, psia; T_g = gas temperature, deg R.

[2] See equation 4 of complete paper.



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Surface Temperature Variations

. . . continued from p. 134

a CFR engine with deposits. The data obtained were used in two ways; first, in an empirical analysis using the slope and maximum-minimum cycle temperatures to compare the deposits formed by various types of fuels, and second, in a theoretical analysis to determine the thermal properties of the deposits, the gas-deposit interface temperature variations, and the instantaneous heat transfer at the deposit surface. Several conclusions may be made from the results:

1. The surface thermocouple provides a simple and effective method with which the influence of deposits on heat transfer can be determined at particular locations in the cylinder in relatively short times.

2. The thermal characteristics of the deposits and their resulting effect on heat transfer are significantly influenced by the chemical structure and boiling point of the fuel as well as the additives used.

3. A small amount of a "dirty" fuel blended with a "clean" fuel is sufficient to cause the mixture to produce deposits that are similar to those produced by the dirty fuel alone.

4. The thermocouple data, coupled with the deposit thickness measurements, make possible the calculation of the thermal conductivity of the deposit and the time-average temperature of deposit-gas interface. This is significant since it is done without disturbing the deposit or imposing any unrealistic conditions on the overall heat-transfer picture.

5. The theoretical analysis suggests a means of computing the heat capacity of the deposit and the deposit-gas interface temperature-time history from the thermocouple data. However, the results of this work indicate that a re-evaluation of the assumptions is in order. Some consideration should also be given to the accuracy of the computational techniques employed.

6. It appears that greater harm due to deposits, that is, decreased volumetric efficiency and high gas temperatures during compression, would occur primarily in connection with nonhomogeneous deposits. This is in direct contrast with the assumption made in the present analysis; however, this subject requires further investigation.

To Order Paper No. 201C . . .
from which material for this paper was drawn, see p. 6.

Electrical Discharges Object of CRC Research

THE first report on an extensive 2-phase Coordinating Research Council project ultimately aimed at defining operating conditions under which electrical discharges in aircraft fuel systems develop has been issued as CRC 346, "Electrostatic Discharges in Aircraft Fuel Systems." This 117-page account of phase one tells how electrical discharges were produced and detected in the fuel flow facilities at Wright Aeronautical Development Center. It also describes installation and detection techniques which were developed to detect sparks and indicate the approximate energy level involved in the discharges.

The CRC Aviation Fuel Lubricant Research Committee is currently conducting an even more comprehensive fundamental research program on this subject.

To Order CRC 346 . . .
from which material for this article was drawn, see p. 6.


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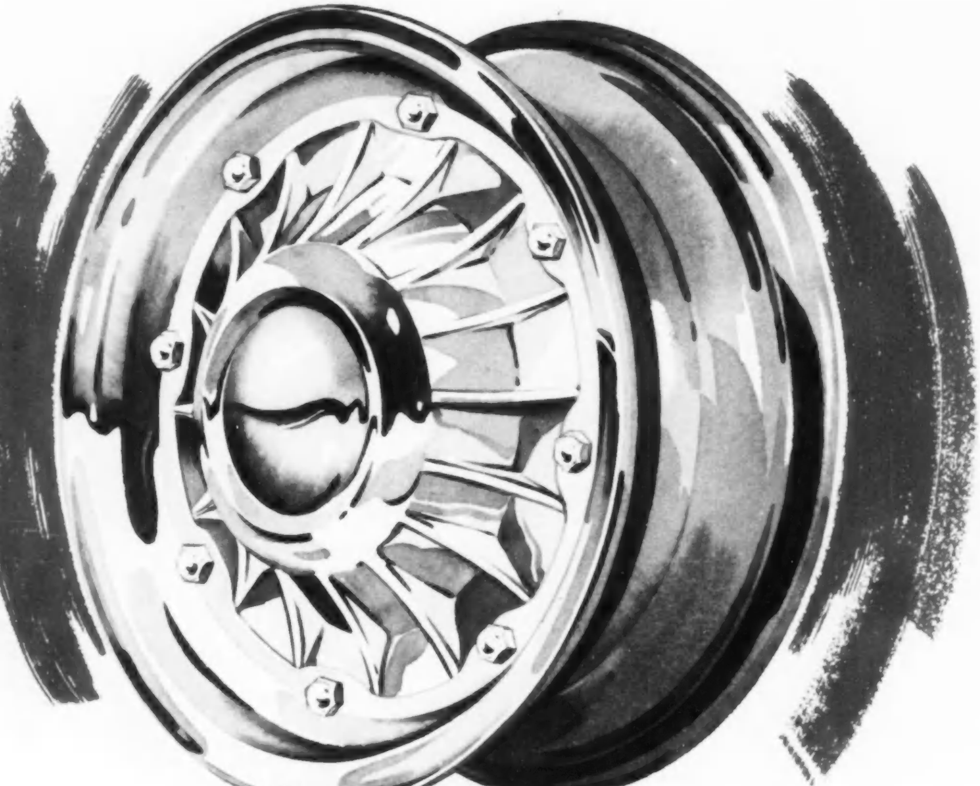

Probing Mechanics of Tire Squeal

Based on paper by

R. F. MILLER and J. G. SLABY*

B. F. Goodrich Co. Research Center

TO make further progress in tire squeal reduction we need to know more about the movements in the contact which give rise to squeal-producing vibrations. How is squeal built up? How is it maintained, and what controls its frequency and amplitude?

To maintain a vehicle in a curved path at a given velocity a certain value of centrifugal force must be balanced by cornering forces in the tires. To develop cornering force a tire operates at a slip angle θ as shown in Fig. 1. The slip angle is the angle between the wheel heading and the tangent to the path through the center of contact. The vector diagram shows the total cornering force developed in the contact and the drag which combines with it to give the operating value of frictional force. When this becomes equal to the total available friction, full lateral skid occurs.

From the standpoint of squeal, the important dimension is the distance *SR*, which represents the average lateral sliding that occurs in the contact. It includes a portion of unaccomplished lateral deflection which results from the limitation of friction as well as the portion of lateral recovery that occurs before the tire leaves contact.

Directions of Sliding

Differences of sliding direction greater than 60 deg do occur in a tire operating at a slip angle of 8.5 deg. The inner edge of the tread moves somewhat toward the rear during lateral recovery. The center portions move almost straight laterally. The outer edge of the tread shows a large forward component in its initial lateral recovery movement. This is thought to arise from the fact that the normal load is extremely high in this region for an outside front tire, so that other regions slide toward it while it still adheres. Thus, it has been left with a rearward distortion when it finally begins to slide. All this leads to a region of buckling in the contact — a region near the outer edge and toward the rear of the contact. This involves a reduction of the contact pressure which

continued on p. 143

* Now with NASA.

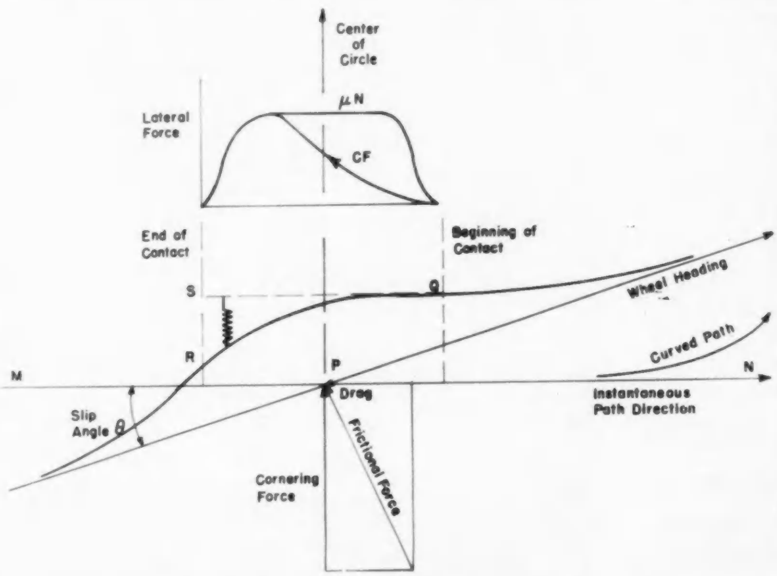

Fig. 1 — To develop cornering force a tire operates at a slip angle θ. The tire is at point *P*, proceeding toward the right around a circle whose center is above the diagram. Before entering contact, the outer edge of the tread has been distorted to a point *Q*. When available friction is exceeded for any area of the tread it begins to slide laterally at constant deflection along the limiting friction envelope μN. The tread leaves contact at *R*. *SR* is the average lateral sliding that occurs in the contact.

The National Automobile Show, direct from Detroit over CBS-TV, 6 to 7 P.M. E.D.S.T.

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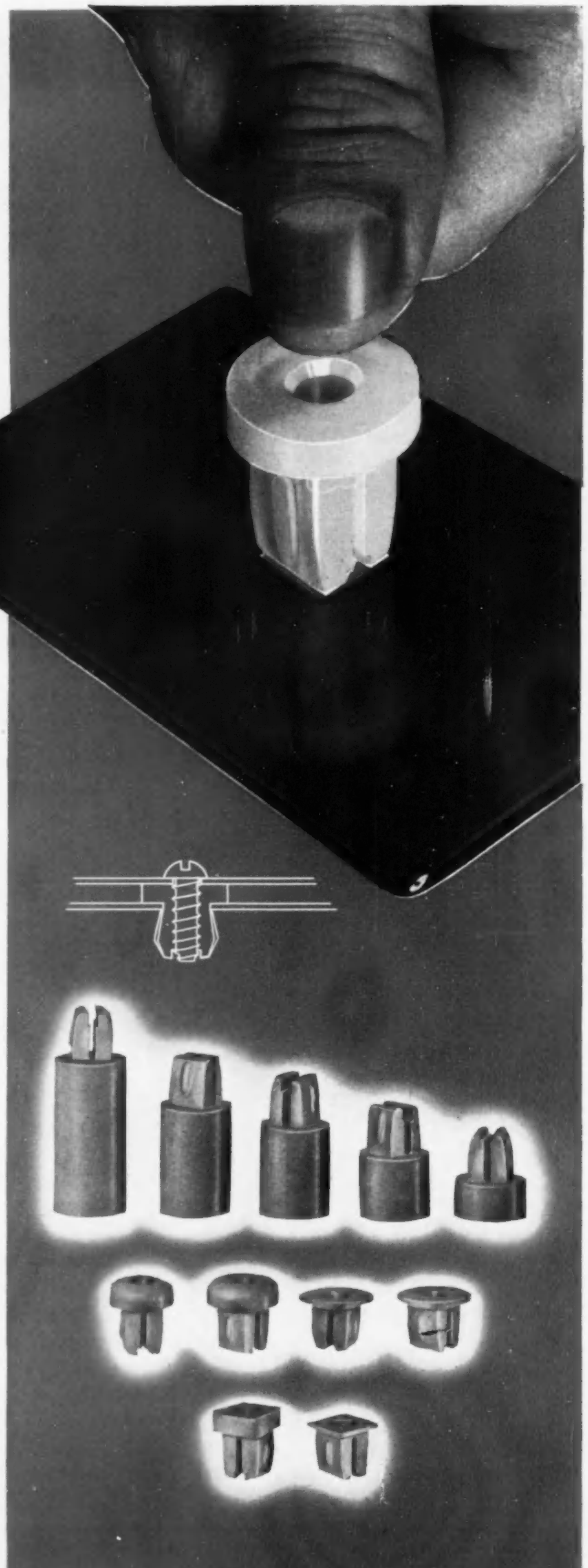

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This versatile fastening device snaps into place under finger pressure alone. Its straight legs permit easy insertion in square, punched holes while the tapered screw hole forces the legs apart when screw is inserted and ensures maximum pull-out resistance. Burrs do not impede the nut or prevent proper seating.

Ideal for use in virtually any type of thin-walled structure of sheet metal or plastic, the DOT Push-in Nut does not chip enamel surfaces, locks tightly without distorting the edges of the hole, resists vibration and serves as an excellent electrical and thermal insulator.

Suitable for use with #8 or #10 screws ... locks in holes from .275" to .292" square ... application thickness range: .030" to .060". Spacer type available with ½" dia. head from ⅛" to 1 1/32" length in increments of 3/32". Other types available in various sizes, round or square-headed, from 1/32" to ⅛" thick.

Engineering details and price information available on request.

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Probing Mechanics of Tire Squeal

. . . continued from p. 141

actually goes to zero in the case being considered.

Importance of Buckling

Vibrations in the tread produce the squeal — they never appear when squeal is not present. The amplitude of the vibratory motion is greatest near the buckled region. Evidently, this region of very low contact pressure is favorable to the storage and release of squeal energy by the tread. A component of the squeal vibration modulates the contact pressure through zero.

An experiment was run in which a small piece of tread stock was slid over a mirror surface with particles of grit to provide a means of scratching the surface. The tread stock was attached to a carriage moving at a constant velocity of 5 in. per sec. Simultaneously, an oscillograph recording of the squeal was made on film. The vibration was discontinuous in the form of small groups of 9–12 waves. Likewise, the sound occurred in bursts. Variations in the number of cycles per burst and number of waves per group in the scratches made it possible to associate first the wave groups with sound bursts and then an individual scratch wave of a group with the sound it created within a burst.

Significance of Scratch Test

The spacing of the vibrations in the scratch were quite uniform during each group. Although a constant spacing in time of the sound pulses within the burst of sound might be expected, the sound appears as a series of damped wave trains, telescoped closer and closer together into a nearly constant amplitude envelope as the burst progresses. The explanation seems to lie in the oscillation of the sample at several different frequencies. The damped wave trains contain frequencies of 2000–3000 cps. The repetition rate of the damped wave trains is 450–1200 cps. They appear to reach the latter value asymptotically with a constant amplitude, "time-saturated" condition.

A low-frequency vibration of 50 cps in the direction of the sliding provided a modulation on the velocity and probably also varied the contact pressure. This combination resulted in a means of starting and stopping the high-frequency or squeal vibration. Also, there seems to be a fairly constant sliding distance necessary to build up the lateral distortion and recovery that causes the squeal.

To Order Paper No. 186D . . . from which material for this article was drawn, see p. 6.


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Polyvinyl Alcohol Quench Is Sensitive to Agitation

Based on paper by

P. E. Cary, E. O. Magnus, A. S. Jameson

International Harvester Co.

AN AQUEOUS SOLUTION of polyvinyl alcohol in a concentration by weight of 0.15% has a cooling ability in quenching steel between that of water and oil. But it is more sensitive to change in quenchant agitation than is water. These are conclusions reached from comparative studies made using various diameter medium and high carbon steel rounds and C-shaped specimens made from high carbon steel. Four degrees of quenchant agitation were produced by use of different quenching fixtures.

That the polyvinyl alcohol solution is more sensitive to agitation changes than is water is shown by Figs. 1 and 2. These hardness penetration curves were obtained from 1¼-in. rounds, quenched with three intensities of agitation.

The cooling curves obtained from the center of a 1-in. nickel sphere when quenched with two intensities of agitation in a polyvinyl alcohol solution showed marked variability with "mild" agitation. "Vigorous" agitation cool-

continued on p. 147

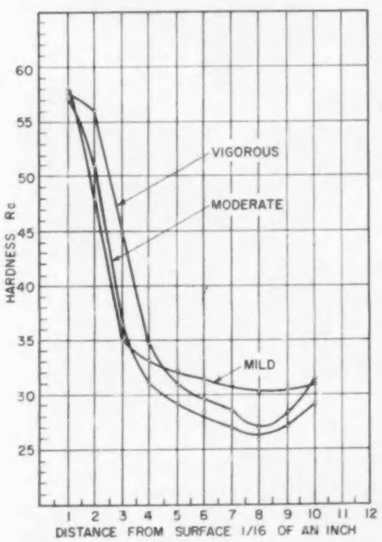

Fig. 1 — Effect of quenchant agitation is shown by these hardness curves from 1¼-in. rounds made from medium carbon steel quenched in a 0.15% polyvinyl alcohol solution at 75 F.

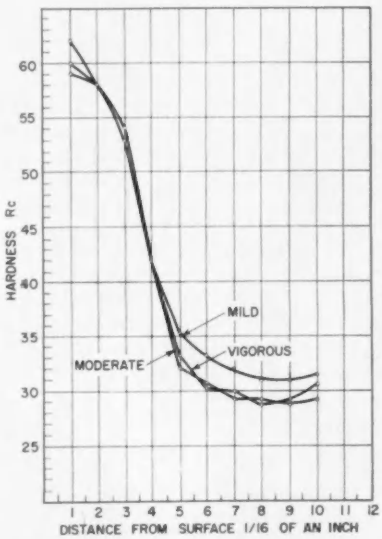

Fig. 2 — Effect of quenchant agitation is shown by these hardness curves from 1¼-in. rounds made from medium carbon steel quenched in water at 75 F.

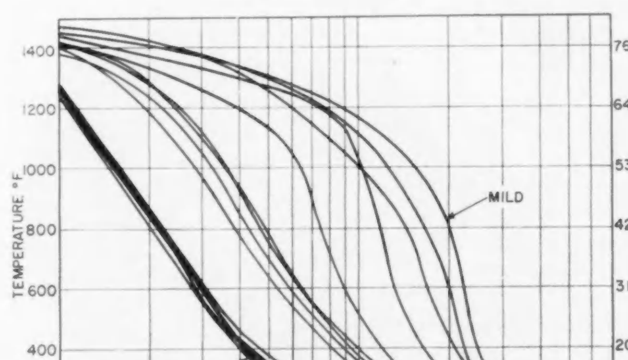

Fig. 3 — Cooling curves obtained from 1-in. nickel spheres quenched in 0.15% polyvinyl alcohol solution at 75 F with "vigorous" and "mild" agitation.

continued from p. 145

concern to the gear designer and must

yond the capabilities of the machine

Central Illinois Section: Harry M. koff (M), James A. Krause (J), Robert

continued from p. 145

ing curves, on the other hand, showed practically no variation (Fig. 3).

In general, a difference appears in the first stage of the mechanism of quenching with these polyvinyl alcohol solutions which requires closer attention to the degree of agitation than is needed with the use of water.

To order Paper No. 178A . . . from which material for this article was drawn, see p. 6.

Communications in Space-System Checkouts

Based on paper by

ROBERT R. DYE

Northair Division, Northrop Corp.

AN electrical system, already in successful operation, provides six separate channels for instantaneous speech communication between any number of people up to about 30.

It is designed to provide the reliable communication necessary among the many people involved — often simultaneously — in accomplishing checkout procedures on sophisticated and complex weapon systems and space systems.

The important parameters for this system are:

a. Magnitude and spectrum level of the ambient noise, particularly in the frequency band of 200–6000 cps.

b. Characteristics of microphones and headsets.

c. Magnitude and spectrum level of various noise sources.

d. Characteristics of the speech channel, including gain, frequency response, AGC, and peak clipping.

This system, which has achieved satisfactory communication in 137 db of white noise, is a unique combination of existing techniques and principles.

To Order Paper No. 241D . . . from which material for this article was drawn, see p. 6.

3 Rules for Successful Transmission Gear Design

Based on paper by

A. HARDY

General Motors Corp.

THREE STEPS to the successful design of transmission gears are:

1. Provide the production department with practical tolerances. These tolerances are a constant source of concern to the gear designer and must be realistic if gears are to be produced economically.

2. Meet the gear specifications set by the engineering department if you are to ultimately satisfy the customer.

3. Use designers that have a knowledge and appreciation of production's problems. The designer should employ this knowledge intelligently to bargain for closer tolerances. He should realize that calling for unrealistic accuracy on the detail of the gear does not necessarily make the part better. When tolerances are beyond the capabilities of the machine and the man operating it, the inspection department will ask the engineering department to make the decision of rejecting possibly good gears or increasing tolerances to pass them.

Compromises are necessary. Engineering, production, and inspection must be a well coordinated team to produce the best gear at the most reasonable price.

To Order Paper No. 208D . . . from which material for this article was drawn, see p. 6.

New Members Qualified

These applicants qualified for admission to the Society between August 10, 1960 and September 10, 1960. Grades of membership are: (M) Member; (A) Associates; (J) Junior.

Atlanta Section: William Walter Bolan (A).

British Columbia Section: Frank H. C. Dean (M), Douglas Stanyer (J).

Buffalo Section: Norman G. Bruinsma (J).

Central Illinois Section: Harry M. Bloom (J), Alvin D. Mayerchin (A), David L. Taylor (J), John C. Thompson (A), Thomas L. Yingling (J).

Chicago Section: Tommy D. Badley (M), Edward E. Braun (A), James F. Davis (M), Allan L. Freedy (J), Arthur E. Nelson (M), Warren C. Schloskey (M), John Schmidt, Jr. (M), Robert W. Vierck (A).

Cincinnati Section: Arnold M. Leas (M), Robert H. Wettach, Jr. (M).

Cleveland Section: Robert C. Brooker (M), Kenneth L. Campbell, Jr. (M), William C. Dalton (A), Peter J. Ghirla (J), M. C. Hoffman (M), Stanley Kalikoff (M), James A. Krause (J), Robert Moran (A), J. Carl Peifer (A).

Colorado Group: Rudolf O. E. Kroeger (M).

Dayton Section: Jerome L. Dorsten (J), John A. Losh (M).

Detroit Section: Albert Willard Armour (A), Phillip G. Arndt (J), Colver R. Briggs (A), Donald T. Cantrell (J), Norman Eugene Coonfer (J), Harry P. DeMoss (J), Archibald C. Doty, Jr. (M), Arthur W. Dulemba (M), Alan Robert Fisher (J), Lawrence H. Gillespie, Jr. (M), William V. Hildebrandt, Sr. (A), Robert W. Himrod (M), Leonard Gustave Johnson (M), John B. Keir (M), Addison B. Kelley (M), Tim Frank Lezotte (J), Roy F. Manley (M), Samuel A. Mazzola, Jr. (J), Bingham Andrews McClellan (A), Gordon Eric Morse (M), Robert Earl Neth (J), Bela Sandor (M), Donald J. Schrage (J), Edwin J. Seiberlich (M), Stephen F. Selby (A), Michael S. Selwa (J), Stanley J. Sobolak (J), Richard M. Studer (A), John Brixton Swetka (A), Charles Henry Torner (J), James E. West (M), Lino F. Widmann (J), James C. Wood (M), Sami F. Zawideh (J).

Fort Wayne Section: Victor N. Farhi (M), William J. Martin (J), Paul Everett Merriman (J).

Indiana Section: Frederic Rigdon Bartlett (J), Jerry A. Dick (J), Ralph J. McDaniel (M), Robert W. McJones (M), R. W. Oyler (M).

Kansas City Section: James Leroy Mitchell (J).

Metropolitan Section: Robert E. Buckley (M), Ivan O. Fieldgate (M), Northrop Rogers Fletcher (M), Willard H. Keeber (M), Roger A. Michaels (J), F. Henry Rossire (M), Kevin Sheehan (J), Donald Kenneth Strout (A), Eugene C. Taylor (M).

Mid-Michigan Section: John A. Zidak, Jr. (J).

Milwaukee Section: James E. Hill (M), Leonard Kube (J), Richard H. Lincoln (M), Donald G. Pohl (J), Otto H. Scharpf (J), Lawrence J. Slater (M).

Montreal Section: Norman Walter Kuster (M), Louis Morin (J).

New England Section: James C. McEvoy (A), Chester L. Menne (M).

Northern California Section: Donald Lee Beers (J), Phillip Alvin Bohm (J), K. Bertil K. Klingborg (A), Akito Ogoshi (J), E. C. Schafer (M).

Northwest Section: James E. Tomlin (J).

Ontario Section: George Stephen Bagosy (J), Richard F. G. Baker (J), George S. Clark (A), Frank X. Gregor (A), Michael A. Haddon (M), Donald A. Jackson (A), Ivor Sidney Piercy (A).

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New Members Qualified

continued

Philadelphia Section: Alexander Tarsi (A).

Pittsburgh Section: Larry Duffield Duquette (J), Lucian J. Leta (M).

Rockford-Beloit Section: Burdette L. Douglass (M), Delmer L. Rench (M).

St. Louis Section: Donald M. Veihman (J).

Salt Lake Group: William S. Watson (J).

San Diego Section: Reinhold L. Gerber (J).

Southern California Section: James Thomas Albert (J), Horace L. Beaty (J), Werner Ron Eschrich (A), Charles W. Eyres (A), Stanley Chester Neff (A), T. W. Proudfoot (A).

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Twin City Section: Calvin H. Schwalbe (J), Donald C. Staab (J).

Virginia Section: Israel Ipson (A).

Washington Section: William J. Neff (J), Daniel T. Pickett (A).

Outside Section Territory: John Richard McCorkle (J), Richard P. Schaeffer (J), William F. Spaeth (M), John Lawrence Twells (A).

Applications Received

The applications for membership received between August 10, 1960 and September 10, 1960.

Baltimore Section: Leonard Henry Forman

Buffalo Section: Thomas Hugh Callen

Central Illinois Section: Lawrence J. Blattner, Sterling Richard Booth, Jr., John Martin Drlik, Allen W. Elliott, James Howard Furlong, Gerald G. Hoeft, Arnold Herbert Janot, Stanley L. Kerker, David Louis Oedewaldt

Chicago Section: John A. Boyd, William V. Burke, Charles R. DeVane, Jr., Joel Arthur Pieper

Cincinnati Section: Jerry W. Bartling, Willard R. Becraft, Robert L. Oelrich

continued on p. 152

Applications Received

continued

Cleveland Section: Chester Patrick Coldren, Richard R. Reimer, John J. Rodgers

Dayton Section: Alvin Clinton Forsythe

Detroit Section: Harry J. Brown, Edward Oliver Cascardo, Fred Easa Ghannam, Frederick E. Kruse, James R. Kuehnel, George Fraser Luckett, Robert Arthur Mallgren, Robert L. Mentzer, Ronald R. Wisner

Fort Wayne Section: Calvin Neil Moulton

Hawaii Section: Jack M. Brown

Indiana Section: Joseph John Clegg, Thomas Joseph Deane, Mark Edwin Fisher, Leonard D. Gardner, James Ross Williams

Kansas City Section: Joseph C. Bouldin, Stanley John Casper, Andrew Edward Kuhar

Metropolitan Section: Gregory Mark Cinque, John A. Ferris, Larry John Fauci, Gene Hopkins, Franklin T. Johnson, Arthur Noble Kugler, Michael C. O'Connor, John J. Pepas, Robert C. Wade, Jr., Ward C. Watson

Mid-Cont. Section: Richard C. Hall, James Leroy Jones, Jr.

Mid-Michigan Section: Harold J. Burke, John R. Gretzinger, Dale A. Marek, Edwin D. Weddington

Milwaukee Section: John R. Dwyer, Jr., Richard Phillip Emmerich, Eugene Pramenko, Russell R. Ruck, Paul Joseph Welz

Montreal Section: Pierre Bellemare, Pierre-Emile Bonin, Claude Coudry, Jean Guy Moore

New England Section: Carl Edwin Beck, Byron F. Blanchard

Northern California Section: Robert Warren Armstrong, Roderick Edward Hussey, Robert Ian McClure, Paul Nelson Price

Ontario Section: Edward W. Castle, Lorne Clifford Clarke, Edward V. Cole, Lubomir Charles Hykel, Robert N. Jackson, Gordon Douglas McCulloch, William Cecil Patterson

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Proving ground for

AUTOMOTIVE CHEMICALS

It starts with a phone call . . . or an exchange of ideas through the mail. Then two men meet and start working together. One is an automotive engineer, the other a development chemist in Dow's Automotive Chemicals Laboratories. Their common interest is an advanced automotive design feature—one in which an equally advanced product of automotive chemistry will play an important role. In the area of cooling systems, for example, several new developments loom on the horizon . . .

EBULLIENT COOLING PROMISES CLOSED SYSTEM, FEWER WORKING PARTS

Originally proposed for vehicle use back in the 1920's, the principle of ebullient cooling was tempting; but a workable system was stymied for reasons which today are obsolete, such as the lack of an efficient coolant. Today, automotive engineers and Dow research chemists with new coolants are taking a closer look.

Ebullient, or "vapor phase" cooling is based on the principle of cooling by boiling. Highly simplified, the liquid coolant in the engine block is "boiled out" and passed to the radiator as a vapor. There it is condensed to a liquid and returned to the engine. Thus, heat is absorbed by vaporization, rather than by the sensible heat of the coolant. Ebullient cooling eliminates the thermostats and the water pumps of the conventional system, and most important of all, it may be a giant step toward the goal of all cooling system engineers —a sealed cooling system!

Ebullient vs. Conventional

At Dow's Automotive Chemicals Laboratories, preliminary tests have been conducted on a passenger automobile matching an ebullient cooling system

Recording temperatures of engine parts in ebullient cooling research.

and a conventional system. The heat transfer coefficients in the valve and cylinder wall areas for the ebullient system were found to be two to three times higher than for the conventional cooling system!

Automotive cooling systems have always been a subject of intense study by Dow's automotive development staff. Dow is a basic producer of ethylene glycol coolants, and through the years Dow corrosion engineers screened many corrosion inhibitor combinations for one that could be used in all sections of the country. Since the main offenders in a cooling system are water impurities and their variants, it was decided to formulate a totally compounded fluid to eliminate the need to add water to the radiator. Thus, after a series of exhaustive performance tests, came DOWGARD*, the world's first year 'round cooling system fluid. A blend of a completely new combination of protective chemicals, and specially treated de-ionized water, DOWGARD gives superior protection to all cooling system metals — including aluminum!

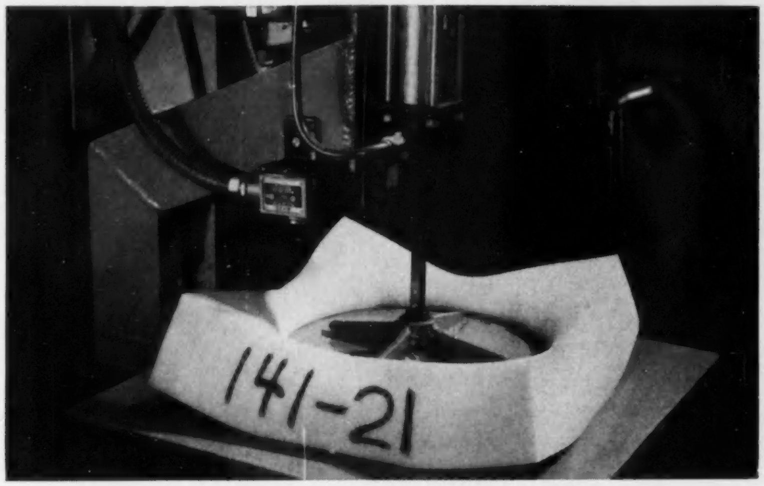
**Trademark*

NaOH: Workhorse in new flake form

The announcement that Dow has introduced a greatly improved new flake form of caustic soda . . . offering higher Na_2O content, and virtual dustlessness

New ground caustic flake is virtually dustless.

has been welcome news to the automotive industry. In many automotive plants, fast-acting formulations containing Dow caustic soda serve as metal cleaners, paint strippers, and waste disposal aids. Quick, dependable supplies of Dow caustic soda are available in all six forms: 50% and 73% solutions, as well as solid, flake, ¼-inch flake, ground flake.



Testing polyurethane foam for dynamic flexing.

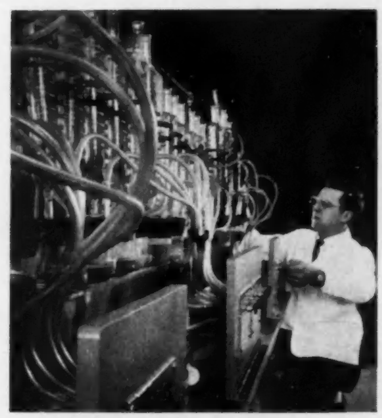
POLYGLYCOLS: from where you sit

In a driver's seat, resiliency, rigidity, and tensile strength are requirements for safe, comfortable driving. In the Dow Automotive Chemicals Laboratories, these are requirements for Voranol*, Dow resin-grade polyglycols used to make polyurethane foam seat cushions. Like the coolants, additives, and fluids that go under the hood, they were subjected to the same exhaustive research . . . are subject to the same high-purity requirements in Dow's automotive chemicals labs. And someday, you may see entire seat assemblies formed of this soft, yet tough material. Or in denser form, they may even be used to make pneumatic tires with a service life of several hundred thousand miles.

**Trademark*

The many faces of amine

Another versatile "soldier" in Dow's array of automotive chemicals, the amines serve the automotive industry as ethanolamine soaps, combined with soluble oils, for lubricating and cooling cutting tools . . . triethanolamine has been used as an anti-corrosion additive in antifreeze solutions and hydraulic brake fluid formulations . . . automotive polishes are based on ethanolamine derivatives . . . and amines are also used as acid neutralizers in oil filters. In short, the amines are one of the vital links in the chain between the automotive industry and Dow automotive chemicals research.

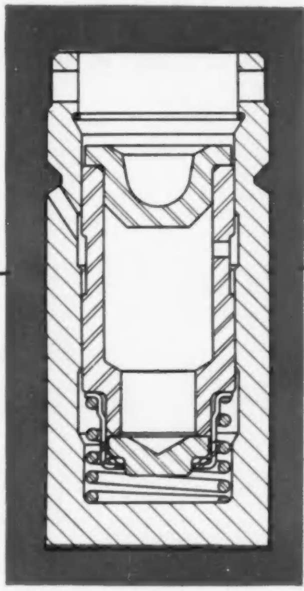


Coolant solutions subjected to a battery of corrosion tests.

• INFORMATION, PLEASE: If you'd like more information on the above activities, or any area of Dow's automotive research, please write us. A member of our technical staff will give your inquiry prompt attention. Write: THE DOW CHEMICAL COMPANY, Midland, Michigan, Chemicals Merchandising Department 401EN10; or contact a Dow sales office near you.

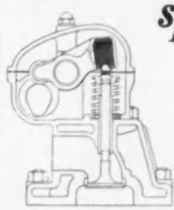
See "The Dow Hour of Great Mysteries" on NBC-TV

THE DOW CHEMICAL COMPANY
Midland, Michigan
DOW



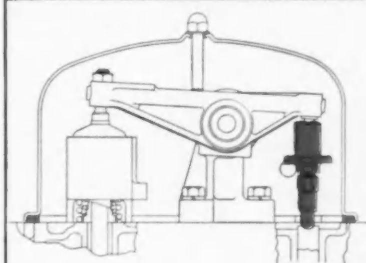
Designing valve gear?

We invite you to use these specialized CHICAGO services

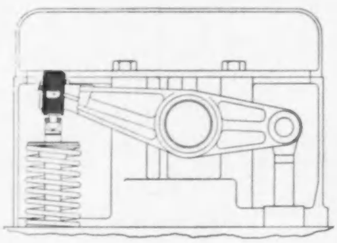


CHICAGO SPRING-LOADED FLAT VALVE HYDRAULIC TAPPET

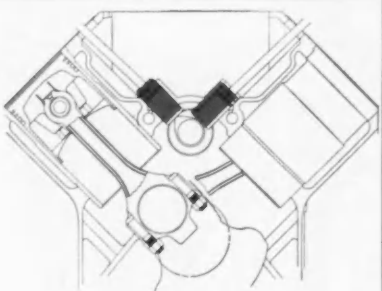
INSERT TYPE ROCKER ARM UNIT



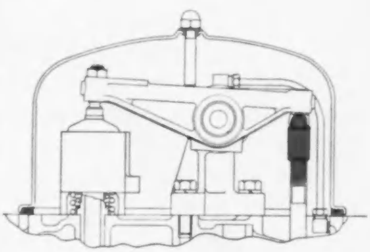
PUSH ROD TYPE FOR COMPRESSION RELEASE APPLICATION



THREADED TYPE ROCKER ARM UNIT



V-8 AUTOMOTIVE HYDRAULIC TAPPET APPLICATION



HYDRAULIC UNIT ON END OF PUSH ROD

Design

of complete valve gear installations for any type of engine . . . passenger car, truck, tractor, diesel, aircraft or industrial.

Development engineering

based on years of specialized experience in valve gear problems. The skills of our engineers will prove a valuable addition to your own engineering staff.

Tappet manufacturing

CHICAGO's facilities insure precision-manufacturing, scientific testing and rugged, trouble-free performance in every tappet. We welcome the opportunity to serve you.

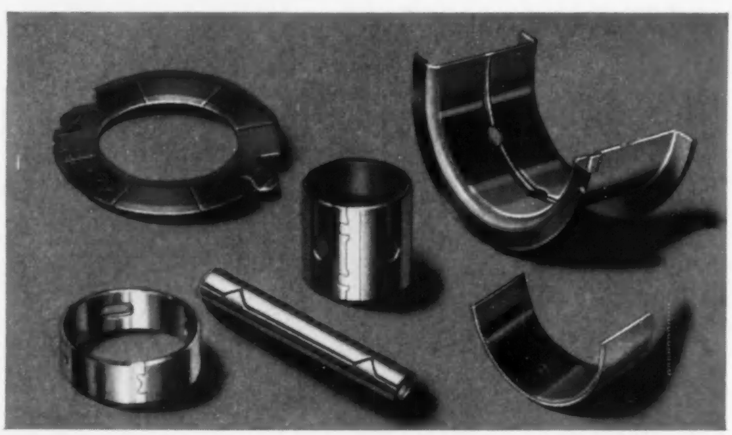
THE CHICAGO SCREW COMPANY

ESTABLISHED 1872 • DIVISION OF STANDARD SCREW COMPANY

2701 WASHINGTON BOULEVARD, BELLWOOD, ILLINOIS

75-MILLIONTHS OF AN INCH BARRIER HALTS METAL MIGRATION

JUST BENEATH THE FRESH OVERPLATE OF THESE F-M ENGINE BEARINGS (LEFT) LIES A TENUOUS DIFFUSION BARRIER. Though this film of metal is only 75-millionths of an inch thin, it stops tin in the overplate from migrating into the lining metal beneath. Its presence is important to bearing overplate performance, particularly during the critical period of engine break-in. Maintaining uniform thinness as well as uniform composition of the plated barrier is most important . . . and most difficult to achieve on a production scale. Federal-Mogul research has developed a unique, extraordinarily precise method for controlling both the thinness and the metallic composition of this barrier, within narrow limits. And the performance of F-M engine sleeve bearings attests to the success of the method!



RESEARCH INTO ELECTROPLATING problems is a continuing project in the F-M laboratories. Unusual precision equipment and facilities are employed, many of which have been specially designed and engineered by F-M to solve problems of sliding-bearing application. As a result, Federal-Mogul engineered sleeve bearings, precision thrust washers, formed bushings, and low-cost spacers provide the finest possible performance characteristics for any application.

FEDERAL Mogul

Have you a problem with bearings, bushings or washers? Are you considering the development or redesign of an item of the type shown above? We'll be glad to show you how the job can be done most effectively and economically. For information, write Federal-Mogul Division, Federal-Mogul-Bower Bearings, Inc., 11035 Shoemaker, Detroit 13, Michigan.

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sleeve bearings
bushings-spacers
thrust washers

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SPICER RUBBER ELEMENT SHAFTS CAN HELP YOU


295

4 new miniature DELCO POWER TRANSISTORS

NOW, FROM DELCO RADIO, A COMPLETE LINE OF SMALL, HIGH-POWER TRANSISTORS!

	2N1172	2N1611	2N1612	2N1609	2N1610
V_{CB}	40	60	60	80	80
V_{EBO}	20	20	20	40	40
V_{CEO}	30	40	40	60	60
I_C	1.5 A	1.5 A	1.5 A	1.5 A	1.5 A
I_{CO}	200 μ a	100 μ a	100 μ a	100 μ a	100 μ a
H_{FE}	30/90	30/75	50/125	30/75	50/125
$V/_{Sat}$	1.0 V	1.0 V	0.6 V	1.0 V	0.6 V

These four new Delco transistors, plus the 2N1172 40-volt model, offer highly reliable operation in a new range of applications where space and weight are restricting factors.

Designed primarily for driver applications, Delco's versatile new transistors are also excellent for amplifiers, voltage regulators, servo amplifiers, miniature power supplies, ultra-low frequency communications, citizens' radio equipment and other uses where substantial power output in a small package (TO 37) is required.

Special Features of Delco's Four New Transistors: Two gain ranges. Can be used on systems up to 24 volts. Can be mounted with the leads up or down with the same low thermal resistance of 10° C/W. Dissipation up to 2 watts at a mounting base temperature of 75° C.

Available in volume production. Write for full engineering data.

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DELCO RADIO
DEPENDABILITY RELIABILITY

Division of General Motors · Kokomo, Indiana

Curtiss-Wright CW-226 with Hi-Torque brakes carries heavy loads, averaging 90,000 pounds of earth.

Contractor gets trouble-free performance with Hi-Torque brakes on rough, hilly terrain

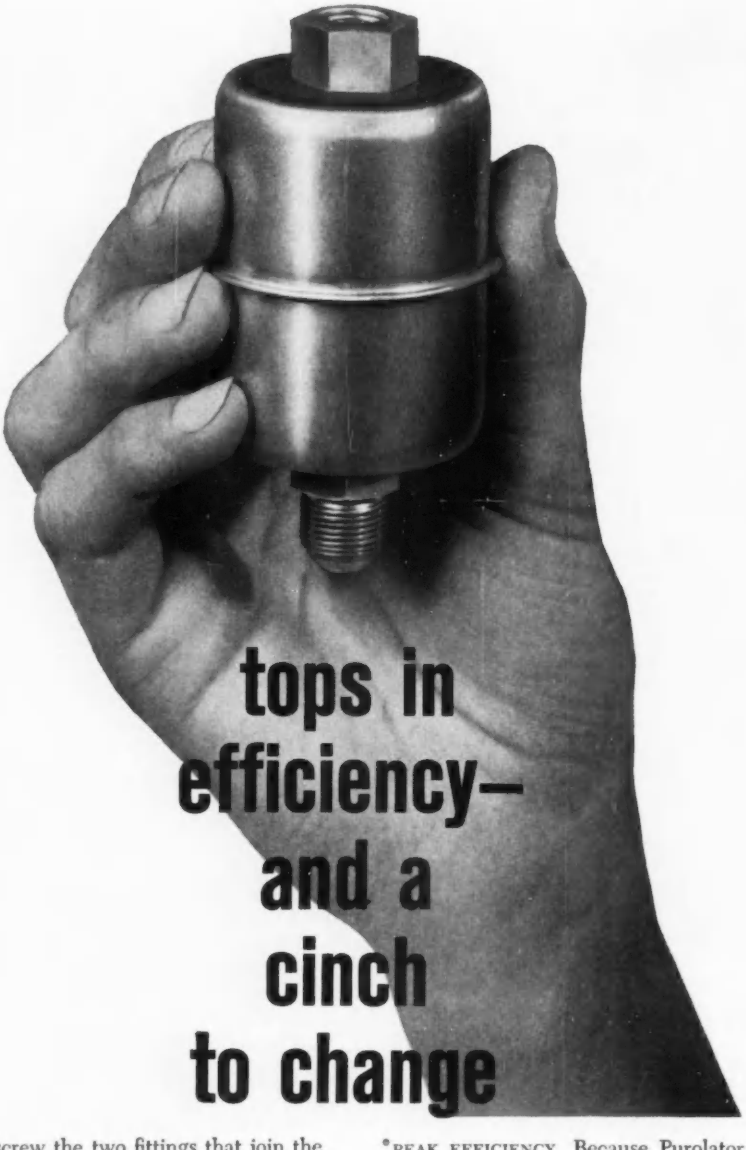
Completely dependable brake performance, with high stopping power always available, has been reported by Talbott Construction Company, Winchester, Ky. Talbott operates several Curtiss-Wright earthmovers with B.F.Goodrich Hi-Torque brakes.

On one project, the machines were in operation on rough, hilly terrain over a six months period, ten hours a day, six days a week. No adjustments, replacements, or maintenance of any kind was required. Dust and water are effectively sealed out, so the environment presented no ill effects. Automatic adjusters maintain proper clearance, adjust for lining wear.

B.F.Goodrich Hi-Torque brakes cut stopping distance approximately in half, compared to conventional two-shoe brakes. These brakes are now available on heavy dump trucks, tractor-scrapers, coal haulers, mine trucks, and other heavy off-highway vehicles, from several manufacturers. For information ask your equipment maker, or write *B.F.Goodrich Aviation Products, a division of The B.F.Goodrich Company, Department SJ-10, Troy, Ohio.*

Hi-Torque brakes permit safe operation on faster cycles.

B.F.Goodrich **Hi-Torque brakes**



tops in efficiency—and a cinch to change

HERE'S ALL YOU DO! Unscrew the two fittings that join the Purolator GF-11 Filter to the fuel line. Throw away the dirty filter. Fasten in the replacement. Now you're ready for 5,000 miles of efficient, trouble-free fuel filtration. Total time involved? *Less than 5 minutes.*

MOTORS RUN SMOOTHER . . . Because this Micronic® filter removes dirt, metal, rust, scale and gum . . . even microscopic particles down to 5 microns.

ADAPTABLE TO ALL GASOLINE ENGINES. Purolator fuel filters like the GF-11 shown above, are standard equipment on most 1960 cars. However, it can be incorporated into the fuel system of almost *any* gasoline engine – automotive, portable or marine.

MORE ADVANTAGES. Easy installation and replacement is a big reason for the popularity of the Purolator GF-11 Fuel Filter. But here are more:

*PEAK EFFICIENCY. Because Purolator replacement filters are inexpensive, and easily installed, chances are they'll be replaced at proper intervals – *and always work at peak efficiency.*

*LONGER SERVICE LIFE. Because of the special pleated construction of the filtering unit, the GF-11 has fully *70 square inches* of filtering surface. It operates longer at peak efficiency.

*COMPACTNESS. The GF-11 measures about 3" by 1⅞". It can be installed either horizontally or vertically.

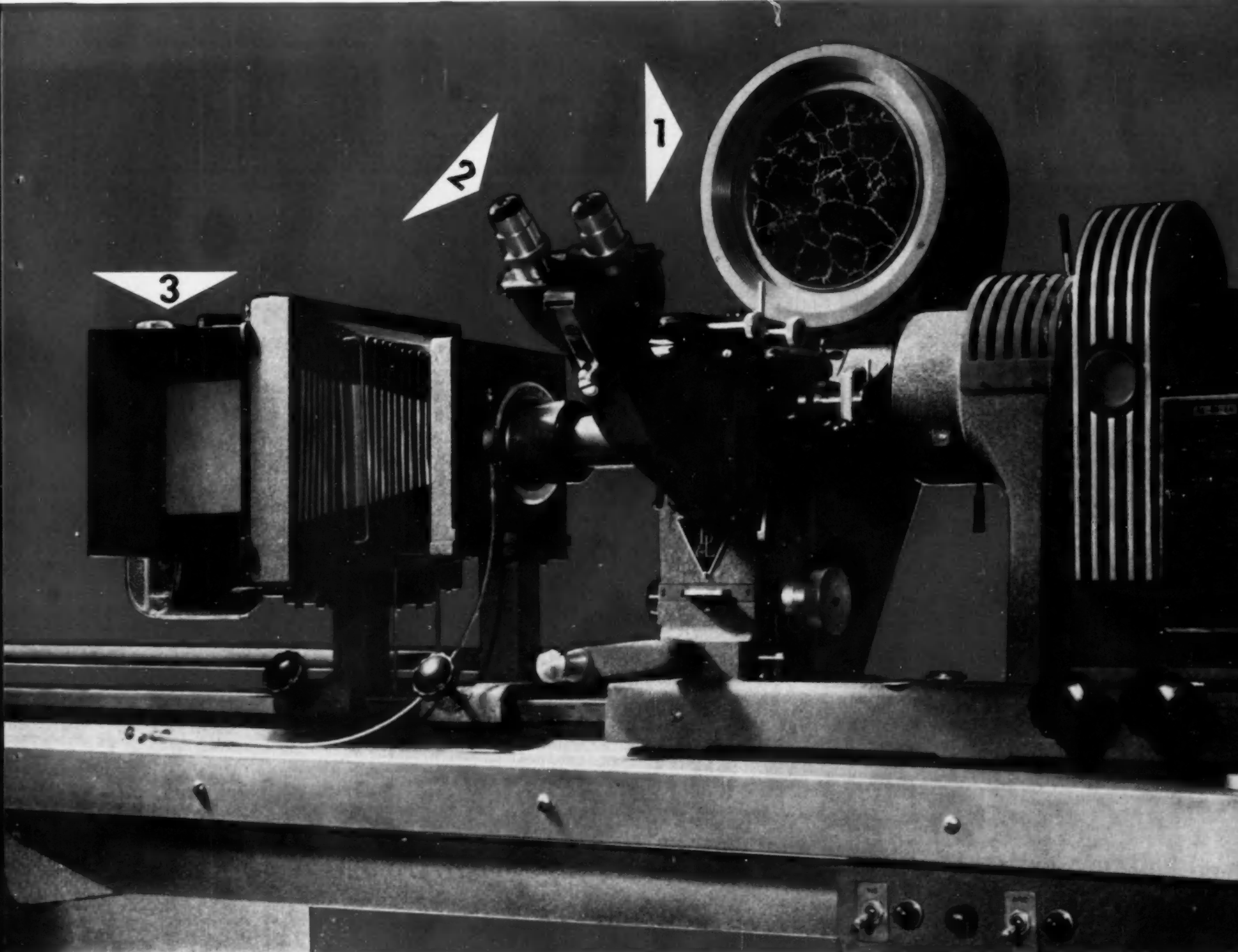
*VERSATILITY. The GF-11 Filter can be installed as an O. E. M. item on practically any gasoline-engine – from sport cars and garden tractors to power mowers and midget racers.

For complete information on the GF-11 and other Purolator filters, write to Purolator Products, Inc., Department 3849, Rahway, New Jersey.

Filtration for Every Known Fluid

PUROLATOR PRODUCTS, INC.

Rahway, New Jersey, and Toronto, Ontario, Canada

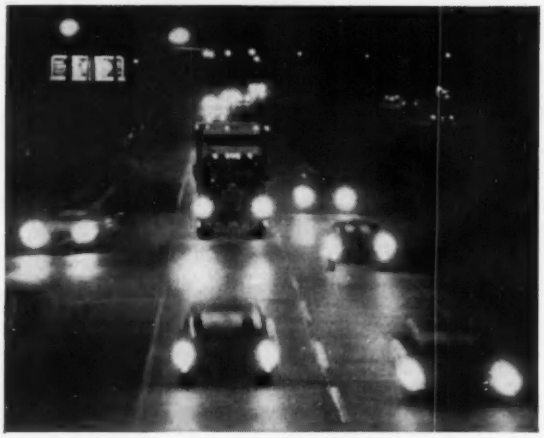

1
2
3

He's looking for tomorrow's headlamp

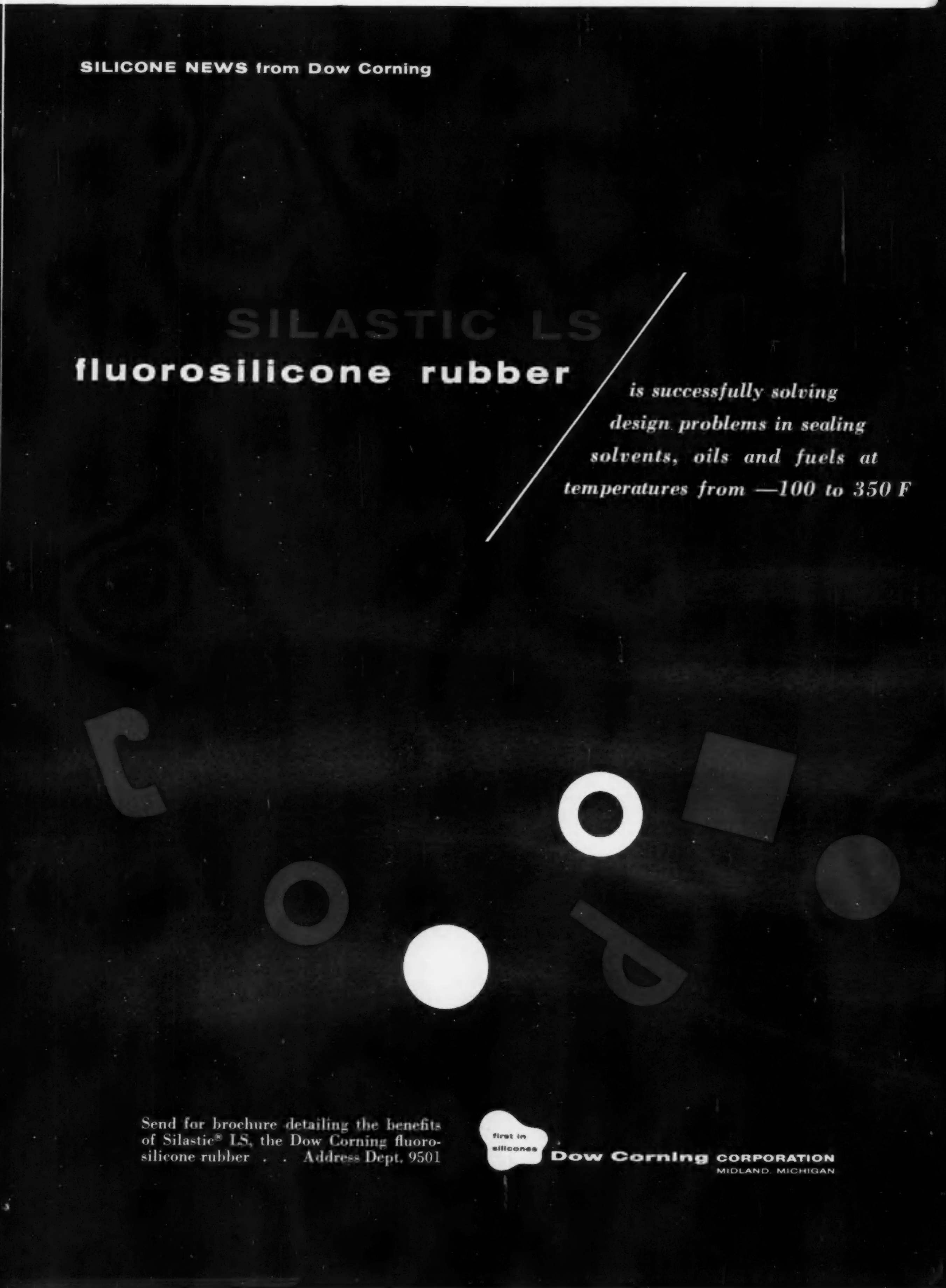
The purpose of this scientific analysis is to develop more efficient headlighting for the cars of tomorrow . . . headlighting that will meet the exacting, yet divergent demands of higher speed turnpikes and heavier in-city traffic.

Here Tung-Sol research and development engineers compare the headlamp beam pattern produced by a newly designed sample lens (right) with that of a standard production model by the use of special aiming heads under laboratory conditions.

This continuing project is an example of the research and development that keeps Tung-Sol to the fore in the quality mass production of headlamps. It is historical fact, too, that Tung-Sol has made significant contributions to major headlighting improvements since the turn of the century when it produced the first successful electric headlamp. Automotive Products Division, Tung-Sol Electric Inc., Newark 4, N. J. TWX: NK193.



TUNG-SOL® HEADLAMPS • MINIATURE LAMPS • FLASHERS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fluorosilicone rubber
is successfully solving design problems in sealing solvents, oils and fuels at temperatures from —100 to 350 F
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SPECIAL NOTICE—
TO ALL PAST, PRESENT AND PROSPECTIVE EXHIBITORS IN
SAE's INTERNATIONAL EXPOSITION OF AUTOMOTIVE ENGINEERING

PLAN NOW FOR YOUR MOVE TO DETROIT'S COBO HALL IN 1961...

Here's What Ward's Automotive Reports Have to Say About the Move:

SAE Annual Convention Booked at Detroit's Cobo Hall, 1961-1965

The Society of Automotive Engineers has engaged Detroit's Cobo Hall for its annual conventions from 1961 through 1965.

The move will give SAE the opportunity of sponsoring what could be the most prominent automotive engineering display in the country and would undoubtedly add authority to Detroit's standing as the motor capital of the U.S. and heart of the industry.

The modern Detroit Civic Center site, currently under construction in the city's bustling downtown waterfont section, is scheduled for opening in August, 1960.

January Dates Set

The SAE business dates firmed up at this time for the 1961-1965 conventions are: 1961 – Jan. 9-13; 1962 – Jan. 8-12; 1963 – Jan. 14-18; 1964 – Jan. 13-17; 1965 – Jan. 11-15.

Cobo Hall will provide the SAE sessions with 400,000 sq. ft. of exhibit space contrasted to just over 10,000 sq. ft. at Detroit's Sheraton-Cadillac Hotel, where the January meeting was held this year.

Membership Swells

It would not be unlikely that SAE will rent exhibit space during its convention to various trades connected with the auto industry for individual expositions.

Textile manufacturers and leather firms would be able to set up equipment to detail their fabric-making processes; rubber makers could show how a tire is made; similar exhibits could be allotted to the replacement parts business; car manufacturers, themselves, might devise cutout working models of engines or even entire automobiles or trucks in simulated motion.

The whole SAE affair could, in fact, house minor conventions for just about every engineering trade allied with the automotive and accessories business.

SAE's expanding membership has been a primary factor in the society's search for larger convention quarters. As of Jan. 1, there were 23,000 members, with the count swelling every month.

Excerpt—Wards Automotive Reports
March 30, 1959

Why Not an Automotive Engineering World's Fair at Detroit's Cobo Hall

Such a structure as Cobo Hall, situated as it is in the manufacturing heart of the auto industry, could be a perfect place for a gigantic technical exhibition —practically a world's fair of automotive engineering – sponsored by the Society of Automotive Engineers.

What a progressive industrial advance would be made by SAE's promotion of a colossal automotive engineering convention-exhibit, particularly with such a valuable location as Cobo Hall available!

Suppliers Could Participate

Parts makers, rubber and tire firms, textiles and leather companies, the metals trades – all of these groups and everyone else with a piece of automotive equipment to show or sell could be provided with the space sufficient to properly present and if necessary, demonstrate his advanced design product.

Cobo Hall's foundations are strong enough to hold heavy equipment such as huge body element stamping presses and various types of rugged metal working machines. The machinery could turn out stampings or tools right in the exhibit area.

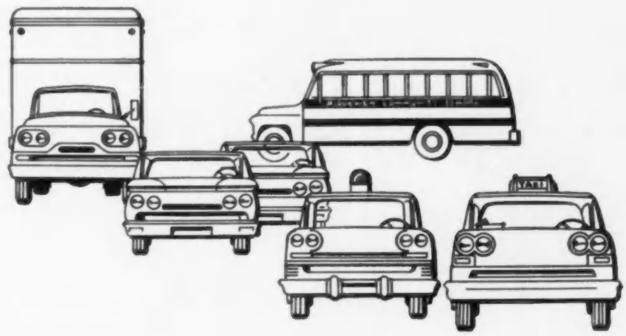
If SAE could come up with such a spectacle it would certainly sweep crowds into Detroit, throngs from various areas of industry and business. The affair could, in fact, house minor conventions for every technical trade allied with the auto and accessories field.

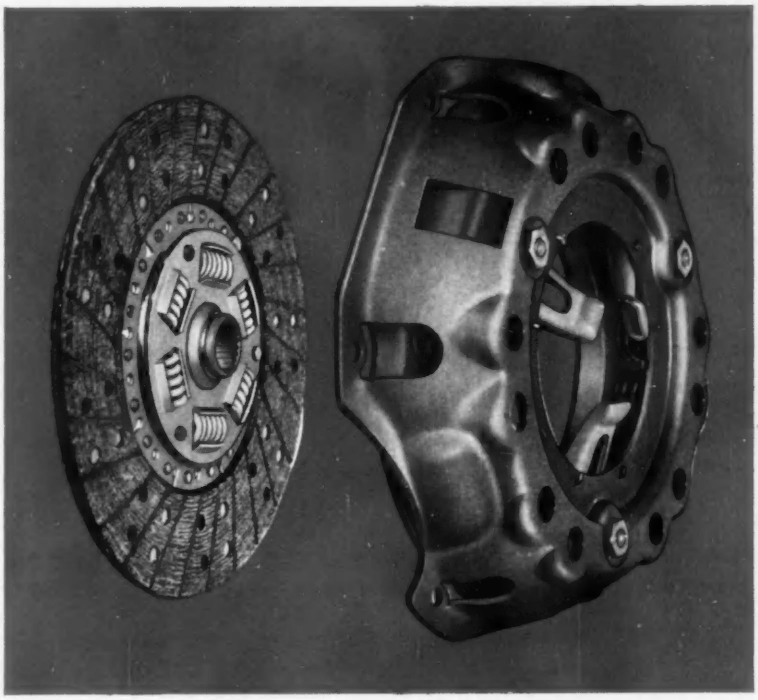
SAE selected Cobo Hall for 1961 and subsequent conventions not only because of its vast exhibit area but for other accommodations as well, including several meeting rooms that seat over 500 persons and a banquet and adjacent room that can hold and serve over 5,000. *Excerpt*—Ward's Automotive Reports

HERE'S WHAT YOUR 1961 AUTOMOTIVE MARKET PLACE LOOKS LIKE:

It's an

New Interchangeable BORG & BECK Clutches for Fleets, Police Cars, Taxis



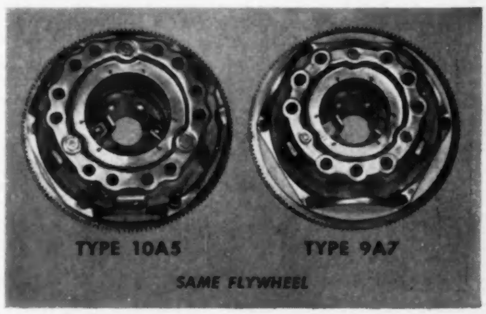


More Capacity—no increase in bolt circle or flywheel size

Now there's no need to change the bell housing, flywheel, motor mounts or pedal linkage when converting cars for fleet, police, taxicab or other heavy duty service. Borg & Beck's new A5 clutches are designed specifically for these installations, as well as for trucks and school buses—provide the additional capacity required, yet are interchangeable with the next smaller size of Borg & Beck Types A7, A8 or A9 clutches.

Type 10A5, for example, mounts on the same flywheel bolt circle as Type 9A7—yet is rated at 265 ft.-lbs. torque capacity compared with 210 ft.-lbs. for the 9A7.

Like all Borg & Beck clutches, the new Type A5 clutches are designed, engineered and built to Borg & Beck's leadership standards for quality, performance and value. That's your assurance of complete satisfaction. Consult our engineers for full details.



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B-W

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THE AUTOMOTIVE STANDARD FOR MORE THAN 40 YEARS

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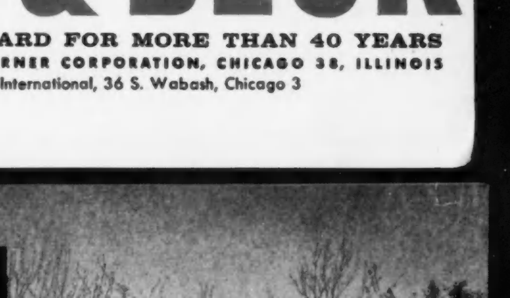
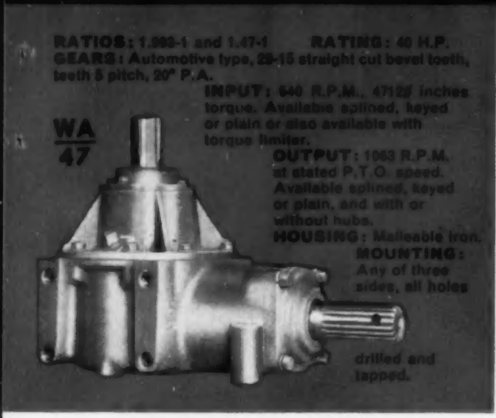
From WARNER AUTOMOTIVE



From WARNER AUTOMOTIVE...



Warner muscle makes mincemeat of mesquite

ROTARY CUTTER CLEARS OVER 5 ACRES PER HOUR—THANKS TO RUGGED NEW GEAR BOXES THAT ABSORB HEAVY SHOCK LOADS—AND TRANSMIT MAXIMUM POWER

To increase performance and so cut costs for owners, E. L. Caldwell & Sons specify 40 H.P. gear boxes—engineered and manufactured by Warner Automotive—America's largest supplier for rotary cutters.

Warner experience in design and production of tough, trouble-free power transmissions increases equipment life, adds to reliability and *salability*.

The WA 47 series speed increaser gear box—with input and output shafts and gears of integrally forged 8620 carburized and hardened alloy steel—owes its superior durability and efficiency also to anti-friction bearings individually calculated for specific loads.

CAPABILITY	SPEED	MATERIAL
1$\frac{1}{16}$ A/Hr.	2¼ MPH	Up to 2"
3⅜ A/Hr.	5 MPH	Up to 2"
5⅜ A/Hr.	8 MPH	Up to 2"

For the Lilliston rotary cutter, the manufacturer specifies the 75 H.P., 57 series gear box—a heavy-duty performer which proves the advantages of Warner Automotive's precision manufacture and quality control.

Rugged gears and shafts of 8620 alloy steel—carefully splined together—put maximum power at the pay-off point of production.

Put Warner Automotive know-how and production efficiency to work for you.

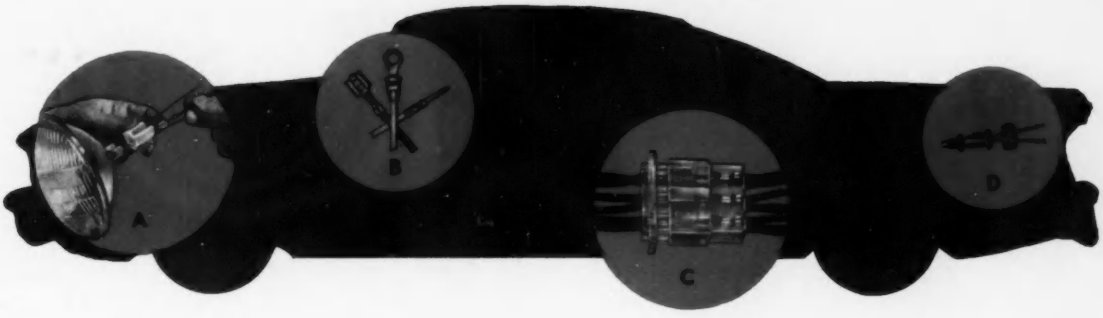
B-W

WARNER AUTOMOTIVE DIVISION

BORG-WARNER CORPORATION ***Auburn, Indiana***

Export Sales: Borg-Warner International, 36 S. Wabash Ave., Chicago, Illinois

IT'S A BETTER PRODUCT WHEN BORG-WARNER HAS A PART IN IT



HEADS OR TAILS . . . OR IN BETWEEN

YOU NEVER GAMBLE WITH AMP. Electrical connections that stand up to formidable vibration, heat, cold and corrosion . . . Consistent circuit reliability and low cost . . . Attachments for every type of automotive circuit application . . . Solderless crimping by Automachine, portable power tools or hand tools . . . There's no gambling when you specify AMP for every electrical connection from head lamp to tail light. (A) FASTIN-FASTON HEAD LAMP CONNECTOR For two or three tabs. Readily disconnectible for easy assembly and saving time. Cycolac housing. (B) SPECIAL WIRING DEVICES Automotive ring tongue and spade tongue terminals, Faston tab and receptacle units and Shur plugs, all to help you with your special single-circuit attachment requirements. (C) FASTIN-FASTON HARNESS CONNECTOR Two styles available: the T-shaped housings for two circuits and the standard housing for six circuits. Quick connect/disconnect of harnesses. Panel mounted or free hanging. Tab width: .250", .205", .187" and .110". (D) BUTTON CONTACTS Positive registry for light sockets. Wire insulation support increases vibration resistance. Permits easy locking of bulb. ***Write today for more information.***

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GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • West Germany

"LIPE CLUTCHES

play an important part in keeping this fleet rolling"

*Philo Edsall, Supervisor of Maintenance for Penn Yan Express, Penn Yan, New York, says**

"I recently took time out from regular duties to review our maintenance records in order to determine which replacement parts were giving us the best performance and service.

"I particularly noted the outstanding endurance of Lipe Rollway Clutches and I thought you would be interested in knowing of our experience.

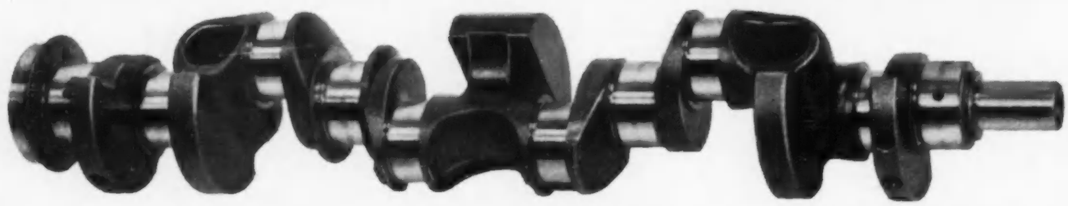
"Penn Yan Express, Inc., operates a fleet of 60 heavy duty tractors, hauling maximum pay loads over a five state area with all kinds of highways and weather conditions, traveling in excess of three million miles annually. Lipe clutches have played a tremendously important part in keeping this fleet rolling. Our records indicate Lipe Clutch performance to be in excess of 175,000 to 200,000 miles."

The experience of this fleet is another illustration of why . . . ***the trend is to* LIPE!**

*There is a Lipe Clutch to meet requirements of vehicles 18,000 lbs. G.V.W. and up; for torque capacities from 200 to 3000 ft. lbs. For application assistance and specific data, contact the Company direct.

LIPE-ROLLWAY
CORPORATION
SYRACUSE 1, N.Y.

FORD'S FALCON CRANKSHAFT...



SHELL MOLDED EFFICIENTLY WITH

RCI FOUNDREZ RESIN!

Ford is mass-producing Falcon crankshafts by the shell mold process – a method as modern as the compact car itself.

And an RCI phenol-formaldehyde FOUNDREZ resin is used extensively to produce the shell molds for this important Falcon casting.

This combination of process and resin provides an economy born of efficiency. Here's why!

The shell mold process offers specific advantages:

- pattern dimensions can be reproduced more exactly
- castings have closer tolerance, require less machining
- shell molds are portable and use less sand
- in fact, foundry efficiency, flexibility and production rate are increased

And RCI FOUNDREZ resins are ideal for shell mold applications because:

- RCI is a basic producer of both phenol and formaldehyde, which guarantees quality control from raw material to finished product.
- RCI's experience, gained during 35 years of diversified synthetic resin manufacture, assures expert technical service.

The advantages of shell molding may apply on one of your foundry jobs. Write to RCI Foundry Division for detailed information on FOUNDREZ resins.

Creative Chemistry . . . Your Partner in Progress

RCI

REICHHOLD FOUNDRY PRODUCTS

FOUNDREZ – *Synthetic Resin Binders*
COROVIT – *Self-Curing Binders*
coRCIment – *Core Oils*
CO-RELEES – *Sand Conditioning Agent*
REICOTE – *Sand Coating Agent*

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N.Y.

INTERNATIONAL S·A·E AUTOMOTIVE ENGINEERING EXPOSITION

COBO HALL
DETROIT
JANUARY 9-13, 1961

Hundreds of companies to participate in

SAE International Exposition of Automotive Engineering

EXPOSITION ALREADY 65% "SOLD OUT"!

BOOTH contracts are pouring in from practically every major manufacturer of "hardware" for ground and flight vehicles for space in a giant "Exposition" to be held in Detroit, January 9–13, 1961.

For the first time in recent years, SAE's annual meeting — the **INTERNATIONAL CONGRESS AND EXPOSITION OF AUTOMOTIVE ENGINEERING** — will be housed under one roof. The site will be Detroit's spacious new Convention Center, the largest in the world.

Some of the companies who have already contracted for space are:

Aeroquip Corp.
Al-Fin Corp. Whitfield Laboratories
Allegheny Ludlum Steel Corp.
Allen Industries
Aluminum Co. of America
American Bosch Arma Corp., American Bosch Division
American Metal Products Co., Unison-Action Seat Division
American Sealants Co.
American Standard, Detroit Controls Division
Ampex Data Products Co.
Anchor Coupling Co., Inc.
Armco Steel Corp., Armco Division
Associated Spring Corp.
Automotive Industries
Automotive Rubber Co., Inc.
The Bendix Corp.
Bendix-Westinghouse Automotive Air Brake Co.
Bolling Wheel & Axle Division, Anderson Bolling Mfg. Co.
Borg-Warner Corp.
Robert Bosch Corp.
Bostrom Corp.
The Budd Co.
Chelsea Products, Inc.
Chicago Rawhide Mfg. Co.
Chrysler Corp., Marine & Industrial Engine Division
Cities Service Oil Co.
Cummins Engine Co., Inc.
Curtiss-Wright Corp., Santa Barbara Division
Clayton Mfg. Co.
Cleveland Graphite Bronze Division of Clevite Corp.
Continental Motors Corp.
Crucible Steel Co. of America
Dana Corporation
Danielson Mfg. Co.
Dayton Industrial Products Co., Automotive Oem Dept., Division of Dayco Corp.
Danco
Delavan Mfg. Co.
Detroit Aluminum and Brass Corp.
The Dole Valve Co.
E. I. Du Pont De Nemours & Co. (Inc.), Elastomer Chemicals Dept., Polychemicals Dept.
Dualoc Drive, Inc.
Dynamic Filters Inc.
Elastic Stop Nut Corp. of America
The Electric Autolite Co.
Enfab, Inc.
Engineering Castings, Inc.
Enjay Chemical Co.
Evans Products Co.
Fawick Corp., Fawick Brake Division
Flexonics Corp., Subsidiary of Calumet & Hecla, Inc.
Ford Motor Co.
Formsprag Co.
Fram Corp., Mfrs. Sales Division
Garlock, Inc.
The Garrett Corp.
Garrison Mfg. Co.
General Motors Corp., New Departure Division
General Motors Corp., Detroit Diesel Engine Division
General Motors Corp., AC Spark Plug Division
General Radiator, Inc.
Gillett & Eaton, Inc.
Hartford Machine Screw Co., Division of Standard Screw Co.
Harvey Aluminum
Heli-Coil Corp.
Hercules Motors Corp.
Hexcel Products, Inc.
Heyer Industries, Inc.
Higbie Mfg. Co., Avon Tube Division
Huck Mfg. Co.
Illinois Tool Works — Shakeproof, Fastex & Spiroid Divisions
The Industrial Press
The International Nickel Co., Inc.
The International Nickel Co., Inc., Ductile Iron Division
Jack & Heintz, Inc.
Jam Handy Organization
Jones & Loughlin
Johnson Bronze Co.
Kaiser Aluminum & Chemical Sales, Inc.
Kelsey-Hayes Co.
Kistler Instrument Corp.
Kolene Corp.
Kysor Heater Co.
Ladish Co.
Lake Shore Engineering Co.
Lapeer Mfg. Co.
Lear, Inc.
Leece Neville Co.
Lipe-Rollway Corp.
Link-Belt Co.
Lisle Corp.
Lord Mfg. Co.
McLouth Steel Corp.
Metal Powder Industries Federation
Midland-Ross Corp., Owosso Division
Minnesota Mining & Mfg. Co.
Misco Precision Casting Co., Division Howe Sound Co.
Molded Fiber Glass Body Co.
Monarch Tool & Machine Co.
Monroe Auto Equipment Co.
Muskegon Piston Ring Co.
National Lead Co., Doehler-Jarvis Division
George L. Nankervis Co.
W. H. Nichols Co
Novo Industrial Corp., United Specialties Division
Novo Industrial Corp., Mitchell Division
Owens-Corning Fiberglas Corp.
Parmatic, Inc.
Perfex Corp.
Radiation, Inc., Defense Products Division
Raybestos-Manhattan, Inc.
Republic Steel
Reynolds Metals Co.
Rinshed-Mason Co.
Robertshaw-Fulton Controls Co., Fulton Sylphon Division
Rockwell-Standard Corp.
Roller Reinforced Plastics
Ross Gear and Tool Co., Inc.
The Satullo Co.
Sealed Power Corp.
Sharon Steel Corp.
Shell Oil Co.
R. H. Sheppard Co., Inc.
Shwayder Brothers, Inc.
Simmonds Precision
S K F Industries, Inc.
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United States Steel Corp.
Union Carbide Plastics Co.
Universal Cyclops Steel Co.
Vickers, Inc.
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Webb Forging Co.
West Bend Aluminum Co.
Whitehead Stamping Co.
Wyman-Gordon Co.
Zollner Corp.

News about
CHEMICALLY ENGINEERED PLASTICS

Throughout the automotive industry, you'll find modern plastics at work. They contribute to the stylish, attractive appearance of car interiors. They simplify production. They even help achieve long life in the equipment used to make and service cars. The continuing development of plastics technology at Dow has provided automotive men with many ways to add to the performance and sales appeal of their product.

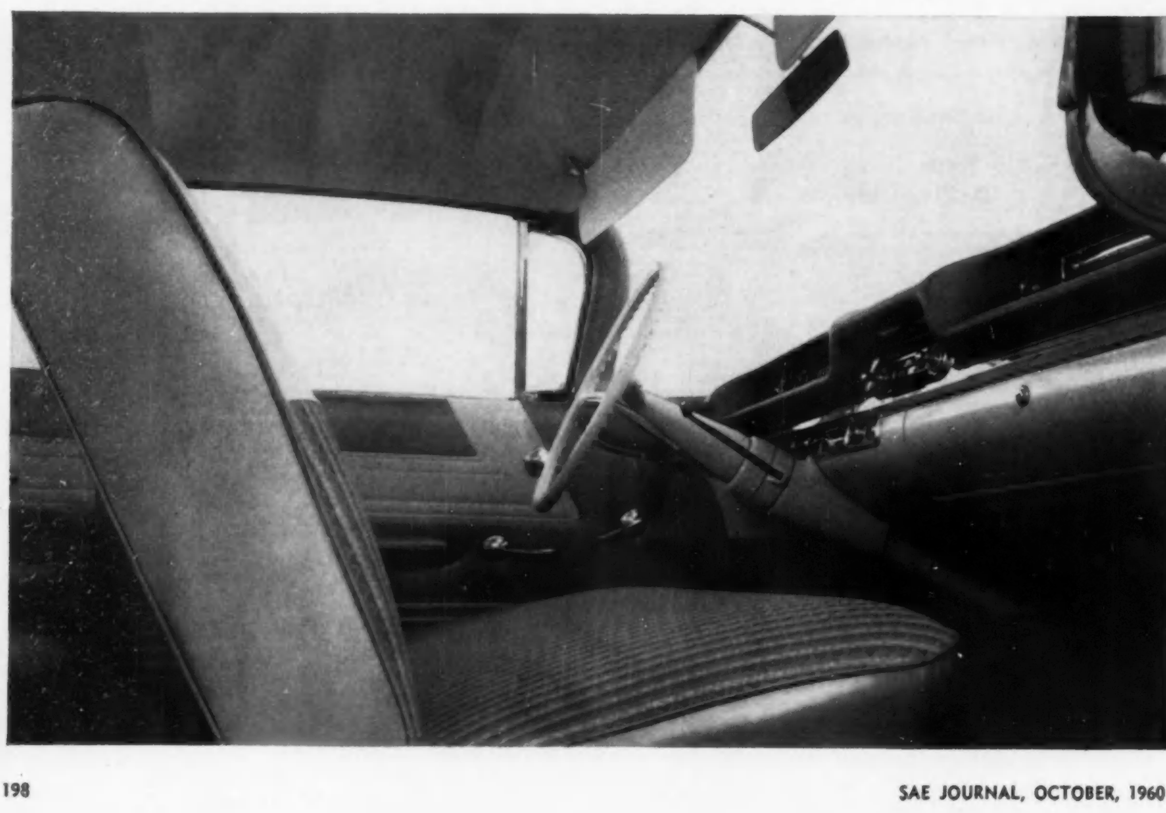
DOW PLASTICS MEET DEMAND FOR PERFORMANCE—AT LOW COST

Today's style-conscious, value-alert buyers place strong demands on a car's interior. Colorful good looks are a must! But over and above appearance, new-car buyers demand hard-wearing, abuse-taking upholstery that's easy to clean.

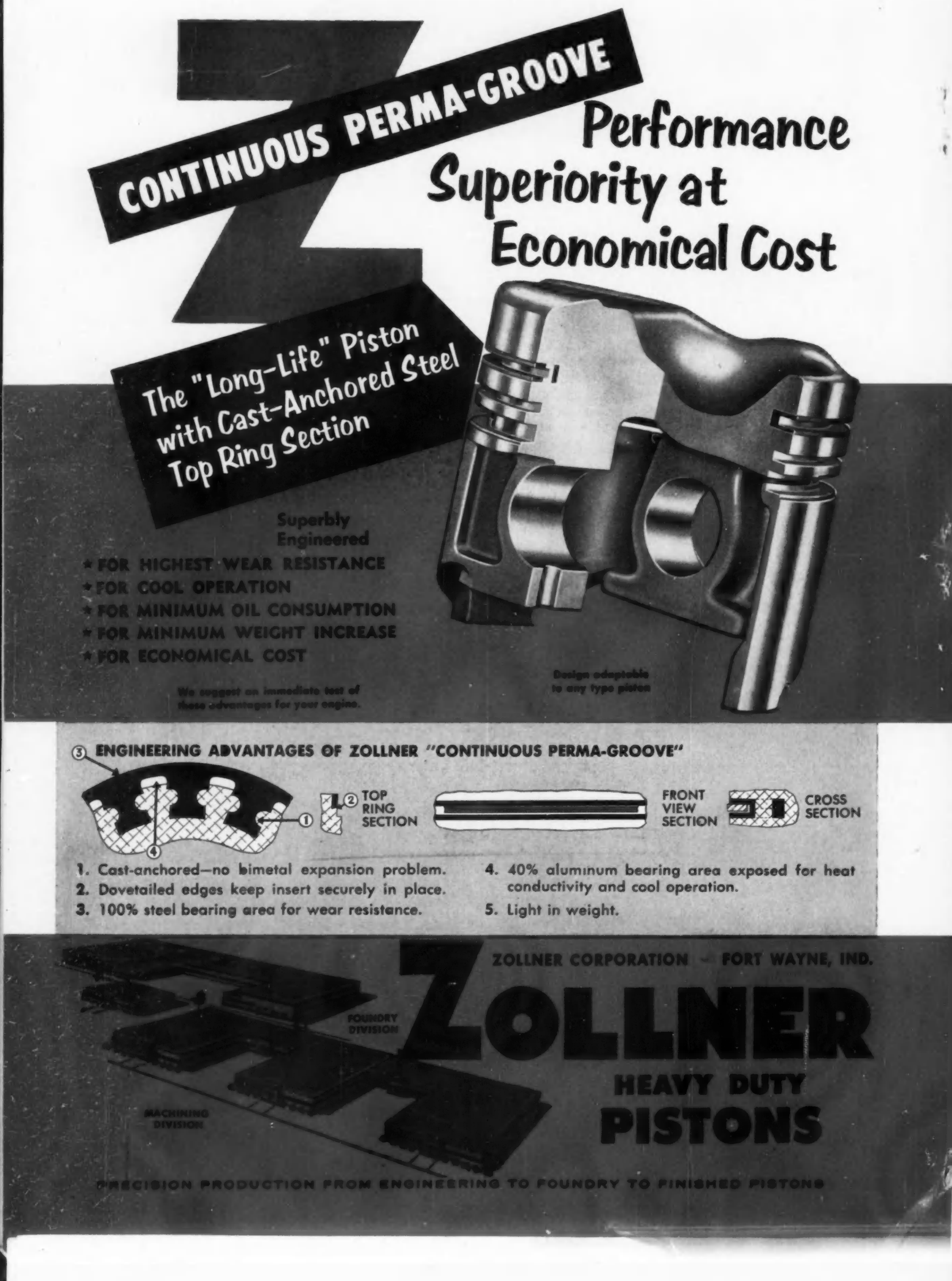
These many customer requirements are met fully with the help of vinyl fabrics made with Dow PVC . . .

Dow PVC (polyvinyl chloride) solves tough fabric problems involving both appearance and serviceability for seat upholstery, side panels and roof liners. With a vast array of colors and color combinations possible, fabrics of Dow PVC can be supplied in any desired surface pattern . . . with the extra value of texture and feel that spell superb quality to the serious buyer and casual shopper alike.

Besides adding eye-appeal, these fabrics have excellent aging characteristics to assure the lasting value of durability. They are cleaned with a damp cloth . . . with warm water and



+ INDEX TO ADVERTISERS +


CONTINUOUS PERMA-GROOVE
Performance Superiority at Economical Cost
The "Long-Life" Piston with Cast-Anchored Steel Top Ring Section
Superbly Engineered
★ FOR HIGHEST WEAR RESISTANCE
★ FOR COOL OPERATION
★ FOR MINIMUM OIL CONSUMPTION
★ FOR MINIMUM WEIGHT INCREASE
★ FOR ECONOMICAL COST
We suggest an immediate test of these advantages for your engine.
Design adaptable to any type piston
ENGINEERING ADVANTAGES OF ZOLLNER "CONTINUOUS PERMA-GROOVE"
TOP RING SECTION
FRONT VIEW SECTION
CROSS SECTION
1. Cast-anchored—no bimetal expansion problem.
2. Dovetailed edges keep insert securely in place.
3. 100% steel bearing area for wear resistance.
4. 40% aluminum bearing area exposed for heat conductivity and cool operation.
5. Light in weight.
ZOLLNER CORPORATION — FORT WAYNE, IND.
FOUNDRY DIVISION
MACHINING DIVISION
ZOLLNER
HEAVY DUTY PISTONS
PRECISION PRODUCTION FROM ENGINEERING TO FOUNDRY TO FINISHED PISTONS

With the right woven pile from Schlegel

Moving this window up or down strains neither muscle nor motor.

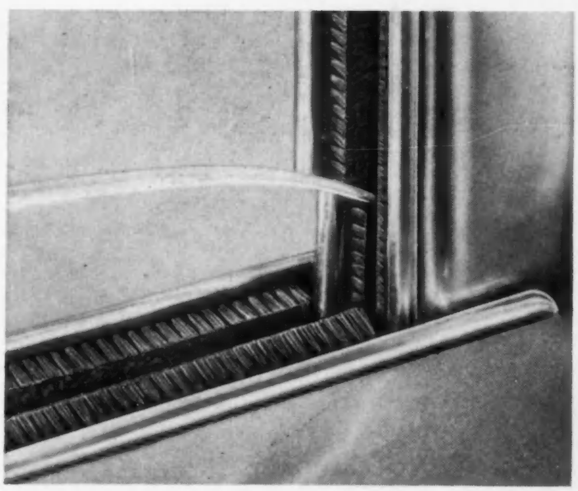
This is a significant accomplishment, considering the glass variances in today's automobile windows How does Schlegel pile liner make the job so effortless—yet still effectively seal out the elements and eliminate window noise?

The answer is yours. You select the glass run channel and specify Schlegel woven pile liner. We furnish the channel manufacturer with pile fabric of the correct specifications.

Our work doesn't end there. We give you a quality pile which will retain its wear-resistance for years and years to come.

To you (and your car-buyer), Schlegel woven pile liner means easier window movement, rattle-free windows and better sealing qualities. It hugs the glass surface evenly, flexing against wavy surfaces to hold a constant seal.

If that sounds good enough to make you want the best, be sure your next glass run channel utilizes Schlegel woven pile liner. You'll be in good company. Automotive engineers have been specifying Schlegel pile liner since glass windows were first used in cars.



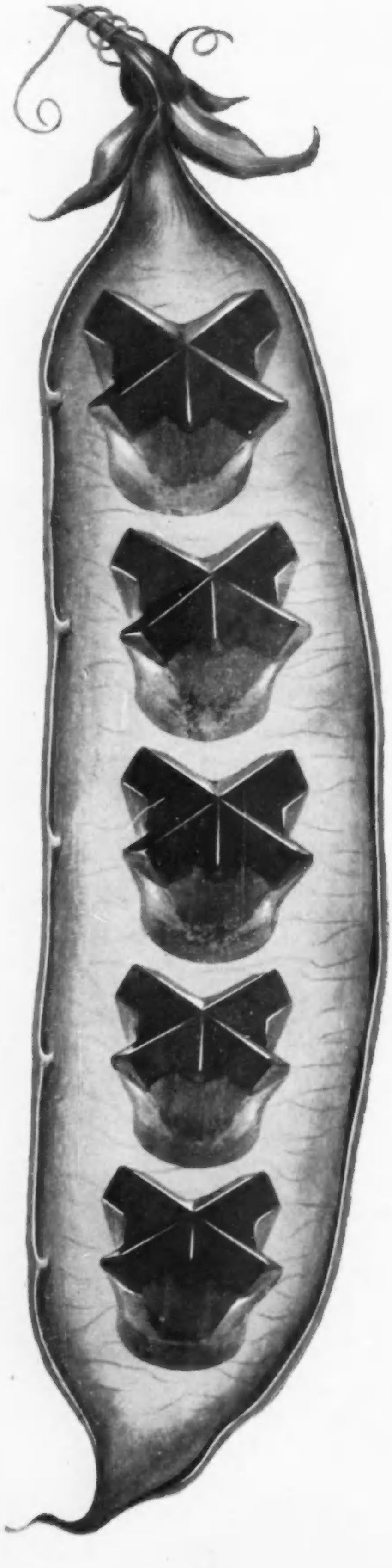
Glass moves friction-free, wet or dry, in this glass run channel with Schlegel woven pile

Schlegel

SERVING THE AUTOMOTIVE INDUSTRY

SCHLEGEL MANUFACTURING COMPANY

1555 Jefferson Rd., Rochester 23, N. Y.
In Canada: Oakville, Ontario



pile liner since glass windows were first used in cars.

In Canada: Oakville, Ontario